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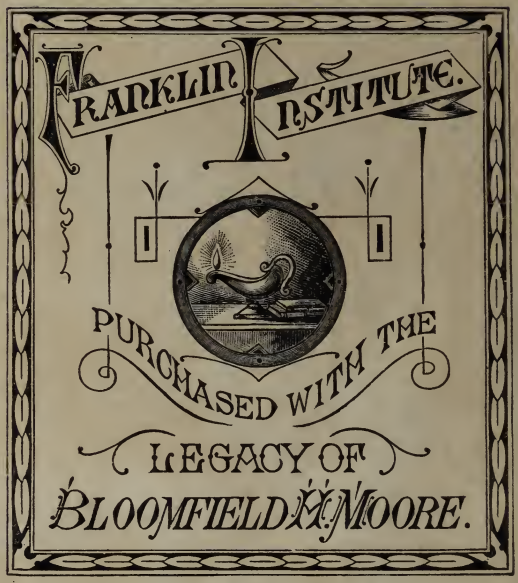
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PURCHASED WITH THE
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BLOOMFIELD H. MOORE.

IRON FOUNDING.

AMERICAN EDITION

A TREATISE

ON

IRON FOUNDING

BY

CLAUDE WYLIE

PRACTICAL IRON MOULDER

SUNDERLAND

ILLUSTRATED WITH DIAGRAMS

SUNDERLAND

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PREFACE.

This volume, although hastily prepared and consequently in many ways imperfect, the Author is induced to publish on account of the importance of the subject, and because much new ground—and that not a moment too soon—has been touched upon for the first time.

Whilst this treatise is intended for the whole of the Engineering profession, it is more especially and confidently tendered to Moulders, who, the Author feels sure, will not fail to appreciate any merit it may possess; but he begs of all parties to be lenient in regard to its blemishes.

To keep the price of the book down, and so place it within the reach of all, the use of diagrams has been avoided as far as possible; still it will be found that illustrations have been supplied in all cases where they were really necessary.

Rules for finding the weight of cast-iron in various forms have been introduced, and will be found very useful.

The author thankfully acknowledges the quotations he has given from the following valuable works, viz.—Dr. Percy's Metallurgy; Tomlinson's Encyclopædia of useful Arts; the British Cyclopædia; the Cabinet Cyclopædia; Bloxham on Metals, their Properties and Treatment; and Spretson on Casting and Founding.

ERRATA.

Page 31, line 13. For "blow," read "below."

Page 100, line 3. For "Sand Moulding," read "Iron Sand Moulding."

"Plate Moulding" begins at page 75, and not at page 77.

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A TREATISE ON IRON FOUNDING.

CASTINGS IN PRIMITIVE TIMES.

IT seems to be generally admitted that Tubal Cain was the inventor of the foundry. There are some who say—Not so: Geology tells us that castings in bronze were made long before Tubal Cain. Be that as it may, it is not our province to question such assertions; but we can safely say that the evidence of bronze castings before the days of Tubal are not very plentiful, and the evidence in many cases must be pure conjecture. We can only go by what records we have; and we find that Tubal Cain, the son of Lamech, is recorded as being the inventor of casting, and, it is believed, the "Vulcan," or god of blacksmiths, of the heathen, (Gen. iv. 22), his brother Jubal being the inventor of Music.

We have no record of what Tubal did in casting or forging; all that we know is, that he could do both, and that he was the first we know of who could do so; therefore we will leave him, and find the next man skilled in brass and iron working.

We find in 1 Kings, vii. 13, that Solomon sent and fetched Hiram, a widow's son, out of Tyre, and as his father had been, "filled with wisdom, understanding, and cunning, to work all works in brass." His first work seems to have been to cast two pillars in brass. Now, the huge size of these pillars in height and diameter is amazing,

and their weight must have been enormous, especially if there was no core in the casting. No doubt Hiram was cunning, or rather (it should read) smart and clever enough to have been able to cast the pillars hollow, and yet it seems strange that no notice seems to be taken of it, if such had been the case; moreover, every thing points the other way, that is, to the assumption that the pillars were solid; because we read that the clay-ground round Jordan was well suited for a foundry, and the brass prepared was so immense in quantity, and the workmen's integrity so tried, that it *neither could nor needed* to be weighed out to them, which would scarcely suit in this generation; but from this account, we may assume that these pillars were really solid. Now let us glance roughly at what their weight would be, if solid.

The height of each was eighteen cubits, and twelve cubits did compass either of them, (we would infer that to be the circumference.) Let us now see what a cubit is.

The Cubit is a measure of length, used both by the ancients and in modern times. The English cubit is half a yard, or 18 inches, and is said to have been originally taken from the measure of that part of a man's arm between the point of the elbow and the extremity of the middle finger; but the Jewish sacred cubit was a hand-breadth more, amounting to 21·888 inches, (Ezek. xliii. 13.) Some imagine the sacred cubit to have been double the length of the common one; and that the pillars in the porch of Solomon's temple were thirty-five common cubits, and but eighteen sacred ones in height, 1 Kings, vii. 15, and 2 Chron. iii. 15; but these texts may be otherwise reconciled, by taking the height of one pillar to be almost eighteen cubits, and the height of both taken together thirty-five cubits. It is probable that the Chaldean cubit was but eighteen inches; assuming, then, that the sacred cubit was only used for sacred purposes, such as immediately pertaining to the altar, we will measure the pillars by the common cubit.

Height 27 feet, and circumference, say 18 feet ; the weight, then, of one column would be something like 175 tons. Hiram would require at least 180 tons of molten brass to complete successfully his casting. We wonder if there would be any scabs on these columns ; of course they would be cast perpendicularly. We wonder how long the casting kept in a liquid state, and if it was fed, and how the metal was run in. We would infer that it was a loam mould, as the foundry was in clay ground. And what shall we say of the furnaces, and how many of them ? and, last of all, what of the appliances for lifting the pillars after being cast ?

Hiram was a Syrian by his father's side, but by his mother's an Israelite ; and we think that he would be cunning enough to core these large columns ; then the thought arises, had they been solid, that the difficulty of breaking them up might have been the means of preserving some portion of them even to this day. Be that as it may, from the accounts that we can glean from the work that he did for Solomon's temple, Hiram was no ordinary moulder ; and he must have thoroughly understood the art of moulding. Hiram's work for Solomon seems to be the only account that we have of foundry work in the Bible ; but we must infer that casting would be carried on in after years.

The casting of bells for churches seems to have been in great favour with the ancients ; the first bell is recorded as being cast at Nola in Campania, A. D. 400. Bede first mentions bells (large ones too) in England, about the year 670, and two centuries afterwards they seem to have been common.

In A. D. 870, according to the historian of Croyland, one of the Abbots of that religious house, gave to the church a great bell, which he named "Guthlac," and afterwards six others, which were all rung together. Lardner says, "the use of bells of a small size is of great antiquity, as in the Jewish ceremonies of the tabernacle, and afterwards in

the temple, bells of gold were attached to the robes of the high priest." The largest bells in the world are, (according to travellers) in China and Russia; and it is said, that at Nankin there formerly hung four bells of such enormous size that, although not swung, but only struck with a wooden mallet, they brought down the tower, and have long lain neglected among its ruins. One of these bells is about 12 feet high, 7½ feet in diameter, and 23 feet in circumference, its weight being computed at 50,000 lbs., or 22 tons, 6 cwt., 1 qr., 20 lbs.

In St. Ivan's church at Moscow, there is a bell which weighs 127,836 lbs., or 57 tons, 1 cwt., 1 qr., 6 lbs. This was the largest bell known, until Boris Godunoff gave to the cathedral of that city a bell weighing 288,000 lbs., or 128 tons, 11 cwts., 1 qr., 20 lbs. This was again surpassed by the bell cast at the expense of Queen Anne of Russia, and which weighs, at the lowest estimate, 432,000 lbs., or 192 tons, 17 cwts. 0 qr., 16 lbs. This is the largest bell in the world; its height is upwards of 21 feet, circumference near the bottom 67 feet, greatest thickness 23 inches. This bell is on the ground. The local tradition is, that the beam upon which it was suspended in the tower was accidentally burnt in 1737. Travellers suspect this to be a fable; but as writers continue to copy each other, the story continues to be repeated. The fact is, that the bell remains in the place where it was originally cast; *it never was suspended.* Lardner says, "the Russians might as well attempt to suspend a first-class line of battle ship, with all her guns and stores." It seems there is a large fracture in this bell, caused through a fire in the Kremlin, the flames of which caught the building erected over the pit in which the bell remained. The metal was thus heated, and the water which was thrown on it to extinguish the fire, caused a large fracture.

On festival days the peasants visit this bell as they would an altar, and cross themselves as they ascend and descend the steps leading to the pit.

Messrs. Clarke and Cripps, who visited this great bell represent it as quite a mountain of metal. It is said that the Nobles threw many pieces of gold and silver into the liquid metal of which it was to be cast.

The bell of which we have already spoken and which weighs 57 tons, is suspended in the belfry of St. Ivan; its circumference is 40 feet 9 inches, and thickness 16½ inches where the clapper strikes; it is only rung on great occasions, and yields the finest and most solemn tones which it is possible to hear, vibrating all over Moscow with a deep and hollow murmur, like the rolling of distant thunder.

The casting of statues in bronze, although belonging to the fine rather than to the useful arts, may with propriety be mentioned here, as it seems to claim great antiquity; specimens of the Greek and Roman workmanship being preserved in various European Museums. Delphos, Athens, and Rhodes, are reported to have each possessed 3000 such statues; the latter place was particularly famous for the colossal image, which bestrode the entrance to the harbour, and which is said to have been thrown down by an earthquake, B. C. 224, and that the Saracens on their becoming possessed of the island, sold it to a Jew, who, to carry it away, loaded 900 camels with the brass.

In what manner the ancients carried on their operations in obtaining casts from statues or models, we are not informed; neither is it known exactly what was the composition of the metal they used. The Egyptian bronze we are told, consisted of ⅔ brass, and only 1 of copper. Pliny says, the Grecian bronze was made by adding $\frac{1}{10}$ lead, and $\frac{1}{20}$ silver to the Egyptian metal. We find that it was in the 13th century that bronze casting began in this country for statuary. The brazen effigies of Eleanor, the Queen of Edward I., King Edward III., and his son the Black Prince; the first, among female figures, and the latter among armed

men, are reckoned the earliest specimens of their age in England. We have ample proof, then, that the art of casting in sand and loam, whether it was for a temple, statue, or a bell, was well known in mediæval times; and the principle of moulding must have been at least as well understood by them, as by its founder Tubal Cain.

At what precise period, and in what country the art of casting in metal began, seems almost a futile enquiry. Mr. Mushet, however, fixes the date of the discovery of the art of casting of iron in this country about the year 1550, and considers the process to have been an English invention. Tomlinson also says, that cast-iron was not known in England before the above period; and that up to that time all articles of iron were forged.

In 1624, Dud Dudley invented the process of smelting iron ore with coal instead of charcoal, and from that date we may say that casting of iron in reality began. Dudley's name deserves to be recorded on the same bright page as that which contains Brindley, Watt, Arkwright, and other illustrious men, who have so greatly contributed to raise England to her present high position.

CORE SAND.

Core Sand, when made into small cores, especially where the metal round about them is light and thin, should be made of weak and *very* porous sand; but it must not be so weak as to lose a certain amount of cohesive nature, to prevent the core being properly made and handled. Two reasons call for this: first, where the metal is thin, it is requisite that the air should pass from the core *at once*; which, if the sand composing the core was strong and close in the grain, would not be the case, and consequently the metal would not lie upon it, and a bad casting would be the result. Secondly, core sand in light castings requires to be open and free, so

that they may come easily out of the casting. A slight rapping of the hammer on the outside of a light casting should cause a core made of proper sand, to run out immediately. To get cores with this property, common moulding sand is freely mixed with sharp sand; in some cases pea meal, with which grounds of porter, beer, or barm, have been mixed. This mixture is only used in exceptionally thin castings. Common moulding sand, as a rule, does well for the most of ordinary cores, and in castings of a fair thickness, where the cores are large. For heavy castings, the sand is different again. It is to be observed regarding it, that the sand must be strong and yet porous, and to get this the following is generally done :—Common sand is mixed freely with loam that has come from loam castings, a certain amount of horse droppings, and in some cases saw-dust; these are put into a mill and ground for ten minutes. The result of passing the sand through the mill, is to make it tougher, or in other words, more cohesive, although with the mixture aforesaid, it still possesses the quality of being porous and open. This sand is termed "mill'd sand," and is only used for large cores, where the casting is large and the metal heavy, Core sand, either for light or heavy work, must be damp, but should it be too wet for small cores, the sand will adhere to the wood or iron core-box, (more especially the wooden ones), and prevent any thing like a smooth core being made. In large cores, if the sand is too wet, it cannot be rammed properly, besides it causes the core to require a needless amount of drying. After a little experience on the part of the core-maker, the requisite consistency is soon attained.

GREEN SAND.

From the words "green sand," it will be obvious to the reader that it means sand in a green or natural state. Any kind of sand will not do for moulding, it has to

possess two qualities; first, a certain cohesiveness; secondly, it must be open and free. Belfast sand is in colour nearly red, of a fine grain, and much used in Scotland for moulding. This sand does well by itself for moulding light work, such as balustrades, grate metal, and all kinds of ornamental work. No sand could be better. But in heavy green sand castings, it requires to be mixed with sand of a stronger nature, and for this purpose rotten rock suits well. This sand seems to be a kind of decayed rock (freestone), its properties are great strength and yet openness. The proper mixture is one of rotten rock to three of Belfast, for ordinary casting; whilst for extra heavy castings, something like equal proportions are used. This sand is used extensively in Scotland, except on the North-east Coast, where principally Erith, commonly called London sand, is used, as it is much cheaper than the sand from Belfast. Erith sand for moulding purposes, is much more useful than Belfast sand, as it seems to possess the proper grain for ordinary castings, and also does well for light work. In extra heavy castings, the part that forms the top of the mould is usually mixed with a little ground fire-clay in the proportion of one to twenty; the fire-clay strengthens the sand, but ought to be carefully mixed, as too much fire-clay might work mischief. The sand that requires to go next to the pattern is mixed with coal dust to the extent that the job requires. Heavy green sand castings, require much more coal-dust than light castings. Coal dust is used for the purpose of causing the sand to leave the casting freely. Ordinary work requires one part of coal-dust to eight or ten of sand, light work one part to fifteen. Belfast sand is all the better when mixed with one to six parts of rotten rock, in order to strengthen the facing of the mould. These mixtures being of the requisite dampness, are riddled through half inch and quarter inch riddles, and are ready for use.

DRY SAND.

Dry sand derives it name, not because it is wrought dry, but because it is dried in the stove after the mould is made and finished. Little need be said of its nature. Foundries which use Belfast sand, make their dry sand of rotten rock and dried loam, in the proportion of one part to ten, and where they have a pug-mill, it is easier and makes better sand to pass it through the mill for a few moments. Where there is no mill it is merely trodden with the feet, turned over, and passed through two riddles. Erith sand is done exactly the same, but dried loam broken up and riddled, would make first-class dry sand without going through the mill. This sand can be of any strength or even closeness in the grain, owing to the mould being put into the stove and thoroughly dried. No coal-dust is used in this sand to skin the castings. It is either before or after being dried, (generally before) blackened the same as a loam mould, with a coat of blacking, (this blacking will be spoken of further on) which is put on with a fine brush, or, which is better, a swab made of lint. Castings made of this sand bring a better price in the market than those made in green sand, as they are cleaner, the metal is closer in the grain, and much better suited for machinery, for reasons which will be given in describing dry sand moulding.

LOAM.

Loam, the Spaniards, not inaptly call "fango" signifying mud, being something like lime in consistency. There are three kinds ; the first called fine or facing loam, used to form the face of the mould ; next, is core loam, presently to be described ; and the third is termed common building loam. The fine (or facing) loam, commonly in use in England, is principally composed of Erith sand, and the mixture is as follows :—Five barrows of Erith to one of old dried loam,

got from moulds that have been used, termed in the foundry "rubbish," and two handfuls of cow hair (the longer the hair the better, as it gives more cohesiveness to the loam), are ground together in a pug-mill, with water sufficient to bring it to the desired consistency. The hair, as it is added, ought to be teased carefully out to prevent it running into lumps. Should the Erith sand be of a strong nature (that is, clayey), one half more of old loam should be added, or a few shovelfuls of fine sharp sand, this will prevent the loam from forming cracks on the mould during the stage of drying. Fifteen minutes' grinding will make it ready for use. Facing loam bears the same relation to a loam mould, as facing sand does to a green sand mould. It is called facing loam, because it is used to cover the face of the bricks next to the casting; the common loam being merely used as a cement for the building of the mould.

Core loam is made exactly the same as the fine, with the exception that three or four shovelfuls of saw-dust, and the same of horse droppings, are added, for the purpose of making it more open and porous. For very small loam cores, where it is difficult for the cleaners to get them out of the casting, it is good to add some charcoal blacking, just sufficient to make the loam black; such are steam way cores for very small cylinders, slide-valves, &c.

The first description of loam is very strong and somewhat close in its nature, and takes a great deal of heat to dry it. When the mould is allowed to get cold after being dried, it seems to absorb a certain amount of moisture, and should the metal be then run into the mould, the casting is liable to be faulty, or "scabbed." Thus with this loam the the mould should be put together when hot, and receive the metal as soon as possible. Some foundries have pipes fitted to enter large moulds, so that hot air may be blown into them during the time of closing, and close up to the time of

casting. Clean castings can be made without such an elaborate arrangement as hot air pipes, if the putting together of the mould is done smartly while hot, when it should still (even the largest of moulds) retain quite enough of heat to ensure no evil result while casting.

Core loam (the second description) is easily broken, and has to be carefully handled, the saw-dust, &c., added to it having made it brittle.

The third description of loam is termed "foundry rubbish," or dried loam off castings, and is only used for bedding bricks, filling up joints, and making loam bricks for cores.

But the loam in Scotland, which is of a very different description, is made from iron sand, coarse in the grain, and full of pebbles as large as marbles. It is the only sand used for making lime, and it is called "iron sand," from being taken from the iron districts of the river Clyde, which supply the West of Scotland. The East is supplied from the river Tay. It is taken from the heads of those rivers to ensure it being fresh. Five barrows of sand are put into the mill to seven shovelfuls of common red clay, and water added till it becomes like lime; it is then ground for fifteen minutes, when it may be taken out for using. Twenty years ago two handfuls of cow hair used to be put into a mill full of this loam, but since that time the hair has been left out, and with equally good results. This loam is much easier dried than the Erith loam, being a great deal more open and free in the grain, the moisture gets better away; when dried it is "frush" and very easily broken, and all tender points in a mould have to be carefully strengthened with ⅜ inch square or round iron. It does not absorb the moisture so quickly as Erith loam, and the mould can be cast with success when perfectly cold. To make the facing part of the mould with this coarse loam requires great labour and skill to bring the mould to a smooth state. A stranger to

the trade looking at a mould when in its rough state, wonders how ever it can be made fit to turn out a fine smooth casting. To plunge your hands among this loam on a severe frosty morning, and build all day with it, is far from agreeable; yet the hands must be used, as the loam requires to be scratched on to the part of the brick which goes next the face of the mould to make it adhere. A mould made from Erith loam is infinitely easier finished than a mould made from Scotch iron sand, yet apart from its roughness the latter is well adapted for loam moulding purposes, and it is to be had very cheap. Rubbish ground into loam is here again applied for bedding the bricks on, and filling up the joints. Iron sand loam for small cores does not require sawdust or horse dung except in rare cases, the sand being merely put through a fine riddle into the mill.

Iron sand loam has, however, its disadvantages. It is bad for the hands, when dried it will break easily, and immense trouble and time are necessary to bring the mould to a smooth state. Against this, you have its singular adaptation for receiving metal kindly; unlike Erith loam, you can drop the melted metal any height upon it, and you may fill the mould when it has been cold for days, and make good castings. The iron sand, being so open and free in its nature, requires much less venting than Erith loam, as it is more open. Any moulder accustomed to work with Erith loam, would find at first some difficulties in working the iron sand loam. First, on account of its extreme coarseness, the difficulty of bringing it to a fine surface; and again, he would be liable to form vents where there was no necessity for them, although this would do no harm, except that time would be spent for no purpose. On the other hand, a person brought up to working iron sand, or Scotch loam, would much more readily fall into the way of working Erith loam, the fineness of which would save him a great deal of trouble, as will be

shewn when we come to treat of moulding with these two kinds of loam. The only difficulty to guard against would be in venting; he might vent too little, and that might lead to bad results; an observant moulder, however, by a little practice will soon get over this difficulty.

Our experience of the two loams leads us to believe that Erith loam is the best upon the whole. It is very much pleasanter to work, and with due care first-class castings can be produced with it.

CORE MAKING.

The word "Core" will convey its purpose to the reader, it being the internal part of a mould round which the metal flows. The "core" is the most important part of a mould, for upon the drying thoroughly and taking the vent off properly, depend wholly the success in making a casting, therefore to insure a sound casting those two things are indispensable.

The apprentice at first begins with making small cores in sand, and this core-making is the gamut of moulding. All the best moulders have, as a rule, been good core makers.

The apprentice, at his outset, has the most simple of cores to make, such as square and round, from half an inch diameter up to three and sometimes four inches, and from two and three up to twelve inches in length, which latter length is generally the limit of a core-box. All cores above two inches in length require something to strengthen them; that is, something for the sand to cling to, and this is done by inserting an iron, of the length of the core, into the centre of the core-box, before ramming in the sand. This iron, of course, must be in proportion to the core, viz. a round or square core of half an inch diameter will only admit of a fine piece of wire,

whereas a core of three times that size will admit an iron of nail-rod; besides this iron, a vent wire must be put in, which must, like the iron, be in proportion to the core. It is laid alongside the iron. Round core boxes are made in two parts, and should be made of cast iron, as boxes made of wood soon become oval; the two parts of the box should be carefully fitted together, then bored out to the required size. The core iron before being put into the sand is made wet with clay water thickened until it becomes like cream in consistency; the box may be rammed either on end, or each part separately; in the latter case a little clay water is run along the centre of each part before joining them together, so that they may adhere; after the core is rammed, the vent-wire is withdrawn, which leaves a clear space through; the core is then complete. Square cores are much easier made than round, as the box being open, is easier rammed. A small hole is drilled in the end of each part of the box to admit the vent-wire being withdrawn.

When the beginner can make these cores properly, he gets others of a more intricate nature, in wood core boxes, and as these are of various shapes and sizes, to suit the different forms of castings, the apprentice has ample opportunities to become a good core maker. He ought to bear in mind, and it is the duty of those over him to let him know, that on making cores carefully and well, at the same time smartly, depends in a great measure his future success as a moulder.

When cores are of a considerable size, the irons to keep the sand together should be made of cast iron, as they are much cheaper, and also more easily taken out of the casting by the cleaners. In large cores the vent wire is not used; ashes do the duty of the vent wire. The ashes should be clean, that is, free from dust. In ramming the sand, a certain quantity of ashes is put into the centre of the core. During the process of pouring the metal into the mould, the gases from

the mould pass easily through the ashes, and from thence to the outlet or vent, which the moulder has provided for their escape. Care must be taken that the ashes are not too near the surface of the core; in that case a risk is run of that portion of the core being destroyed, it being weak in that part. Of course when that takes place it would be a bad casting. In iron sand two or three inches is quite a safe distance to leave. Erith sand would do with half of that distance, being closer in the grain and tougher, and consequently more able to resist the pressure. The core maker should bring his ashes close to the place where the vent is intended to be taken off by the moulder who is going to use the core, and it is the moulder's duty to see that his core is properly dry and the vent good before he puts the core into the mould; the larger and freer the vent is all the better; in fact, the gases from a core cannot come off too quickly.

It has been said, and by experienced moulders, that a core 12 inches square and completely surrounded with metal, could be ventilated with a tube one-eighth in diameter; but we have not yet known the moulder who has done it. We, however, believe that it might be done, but not in ordinary castings. For instance, if the core was made very strong, and the metal round it was not less than three inches thick; but with an ordinary thickness of metal, say one inch, it would be madness to cast it with such a vent. The least vent that ought to be used in a core of that size should be half an inch. But that is not the principle a core maker should go upon; the larger he can get his vent the better for the casting; if the vent cannot be made large, then let him arrange for more than one vent. Ashes make the best vent that can be used in cores, because being so porous, they absorb a certain quantity of gas, and they also afford free passage for the gas that they cannot take in to pass away to the place intended for its exit; and we may even mention

another reason, and a very important one; that is, should metal, through inadvertance or through a weak part of the core, find its way among them, it seldom does any harm to the casting, unless the metal travels right through them and chokes the outlet, which would cause serious consequences; this, however, seldom takes place.

Some foundries adopt straw or hay ropes to form vents in loam cores, especially for steam passages in cylinders. Cores of that kind, although many good ones can be made with such vents, are not quite so safe as those made of ashes, the danger being that in some parts of the core the straw may come too near the surface, and cause a small crack, admitting the metal into the vent, which may run from end to end of the core, and thereby cause a bad casting. This does not happen with ashes, as the metal cannot run far until it sets. Straw or hay were much in use for cores twenty years ago, but are now almost wholly discontinued, ashes having taken their place.

In jobbing foundries pipe cores for three-inch pipes are still made with straw ropes; an iron tube an inch bore and twelve inches longer than the required length of the casting, perforated every four or five inches with $\frac{3}{16}$ in. holes, is covered with a small hay or straw rope, and afterwards with a coating of loam up to the size of the inside of the pipe required. The small holes in the tube convey the gases from the loam into the tube, and it thus passes freely out at both or either end. Care must be taken not to burn or even scorch the straw. Many castings are lost, and even core tubes destroyed, through parts of such cores having been subject to too much heat, which burns out the straw, allowing the metal, if the core should break, to get into the tube or core bar.

Cores for columns are made in the following manner: The core is made of a size to suit the column; for instance, a column twelve inches diameter, and the metal an inch thick,

should have a core ten inches in diameter; this would require a hollow core bar of cast iron six or seven inches diameter, perforated like the smaller one, with holes nine or ten inches apart, the holes being larger than for the smaller one, or about $\frac{3}{4}$ inches diameter. These holes are either round or square.

One course of straw rope is enough for any diameter of core, more do no good, although under certain circumstances four and five courses are used. As when a foundry has not a core bar to suit exactly, and only a few castings are wanted, to save making a suitable one, they use a smaller one, and make up the deficiency with ropes. Now, the evil of this is, that if the core gets too much heated in the stove, if even not exactly burnt, it becomes what is called "baggy," that is, slack on the core bar through contraction. Assuming this core to be for a column cast horizontally, and ten or twelve feet in length, and that the core maker has even raised one or two studs of iron from the core bar to the surface of the core to stay it in its place, even then the column may be thin on the top of the casting to the extent of $\frac{3}{16}$ inch, the bar having perhaps retained its place, but the whole body of the straw ropes and loam being slack, the core has been lifted by the pressure of metal. In this way many pipes, and columns for important structures, are thin on one side.

Again, cores made with such a body of straw ropes are very difficult to dry, and if they are not *quite dry*, the inside of the casting will be sure to be faulty. For fear of this the core maker is liable to heat the core too much. Cores of this kind, to ensure them being well made, should be put into the stove after each one or two courses of straw, well rubbed with loam, have been added. We will assume that a core still wants three inches to bring it up to the required size; a board with a bevelled edge is laid upon the trestles on which the core revolves, and kept back $\frac{3}{4}$ of an inch, loam is then well rubbed over the core until the space is filled up;

it is then dried again, taken out, and the same board kept again $\frac{3}{4}$ back; this will bring it up to the required size, and a strong and safe core is made in this way. A core will take a little more time, but all things considered, it may be said to be quicker in the end than running all the ropes on at once, as you are sure of a casting of equal thickness. In foundries where pipes are made a speciality, the cores are machine made, with only $\frac{3}{4}$ to 1 inch of loam on the bare core iron.

VENTING CORES AND MOULDS.

To know how and where to extract the gases from a core or a mould, is one of the most important acquirements of a moulder. Castings are often faulty, (and even sometimes bad,) through too little attention being paid by the moulder to the minor parts of a mould, or giving little attention to a small core. Take, for instance, a snug, or a flange, where small cores are put in the mould to save boring in the casting. How often have we seen these snugs and flanges blown to a shell, (or rather like a shell,) and the snug or flange having to be burnt on afterwards, thereby endangering the whole casting, and this occurring often, from the want of a vent in the core. And more especially does this apply to small castings, where the metal is light, (or thin,) and consequently little or no pressure of metal in the mould. The higher part of a casting, where the pressure (or weight of iron is least,) seems to suffer most from the want of a vent in the core. Small cores in the bottom of a mould of an ordinary size, (either in loam, dry sand, or green sand,) seem to cause no trouble or harm to the casting, or even mid-way of a mould, and such can only be accounted for by the part of the mould where

they may be located in, having a greater pressure of metal than the strength of gas that the core may contain. When the moulder is satisfied that such is the case, a vent in a small core can be dispensed with.

We will not say that snugs and flanges are blown in every instance, owing to the want of a vent. They are often blown (more especially in green sand) through the cores becoming damp, having absorbed this dampness from the mould, they having been put in the mould, possibly, five or six hours, or even longer, before the mould was cast, in this case, they have the more need for a vent. Too little attention in many instances is given by moulders to those little cores on the top of their moulds, and more especially, as I have already mentioned, does this apply to small castings.

Again, something else is to be considered. Why it is imperative that small cores should be vented, and that is, the state or condition of the metal during the process of casting.

When the metal is hot, or lively, being in a very liquid state, the want of a vent will affect the casting scarcely so much as it does when the metal is in a dull or cold state. In the hot state, the metal is more able to maintain its position or place in the mould, having life in it, as it were, to resist and combat the gas that may find its way through the porousness of the sand which composed the core ; but, withal, the part of the casting is liable to be blown to a certain extent.

When the metal is dull or cold, having little or no life in it, or even moderately hot, the blown part will be much more extensive than when the metal is full of life. In this stage it soon becomes dead, or (technically speaking) *sets*, and the space round the core is vacant, only a shell remains, merely shewing the outside formation of a snug or flange.

Fig. 1.

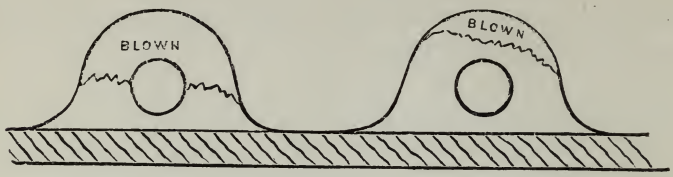

Fig. 2.

In diagrams 1 and 2, we have a view of two snugs, and a flange, as they occur often when cast without a vent in the core, or when the core has been a long time (say twelve hours) in the mould, and has become damp. The snug that is most extensively blown seems to point to any of the following causes :—

First, the core having no vent, or, having a vent, due provision not being made by the moulder to take it away.

Secondly, the core being damp, with a vent in it, and having been taken off, but the metal has been dull when cast,

Thirdly, the core may have been made of very strong sand rather damp, and rammed too hard, and yet having a vent in it.

The snug not so much blown may have had any of the above-described cores, but the metal was in much better condition, being *hotter*.

The flange shewn in No. 2 diagram, has been affected by the same causes as the snugs were ; and although other agencies may cause a blown part in a snug or flange, (as we have already shewn,) the want of a vent is the primary one.

The snugs and flange present this appearance when they form the highest part of a mould or casting, with their edges looking up ; but when they are on the flat, the blown parts are not so deep, the gas finding a wider range over the surface. With the flange on edge, all the gas is confined in a corner, and remains there, to the exclusion of the metal.

When we thus see the importance of attending to small cores, such as inch round, or square, up to three inches, what shall we say of large cores.

Every moulder who may have cores in the piece of work that he may be engaged at, looks and notes with some little anxiety, during the time the metal is being poured into the mould, if his vents are all burning clear.

When a vent from a core becomes stopped with metal, either from the metal having found its way into the core, or from the core changing its position in the mould, and allowing the metal to come in contact with the outlet of the vent, but not in a sufficient quantity so as thoroughly to obstruct the vent, the flame from the gas will be quite different to what it would be if there had been no metal in the vent at all ; when partially stopped with metal, it emits a deep yellow colour, not unlike the flame from coal. When the vent is free, and the core thoroughly dry, a deep blue flame, tipped with a bright yellow, is then seen. The gases from carburetted hydrogen and carbonic oxide, on coming into contact with the atmosphere, cause this blue flame.

A partial obstruction of a vent seldom causes any bad result, if we except some instances, such as when the core is totally surrounded with metal ; to wit, pistons, cylinder

covers, steam ways for cylinders, or in other castings where the metal may be very thin.

Cores are always safer vented from the top, as the gases naturally seek to rise; but when this cannot be done, a pipe (two inches or more in diameter) should be laid in the bed of the mould, immediately below where the core is intended to rest, and careful provision made that it is kept there. When in a loam mould, it can be bolted down to the plate that the mould is built upon. When in green or dry sand, a chaplet on the top will suffice; the chaplet of course to be in strength proportionate to the core that is to be kept down.

When the vent passes from a core through the side of a mould, either sand or loam, that core should be held to its position by means of a bolt, or in some cases, when the core is small, a strong wire will do equally as well; the bolt or wire being made fast to the core iron, so that in the event of the mould slightly yielding during the cast, the core would be held to its place. We believe, that wherever there is a possibility of doing it, all cores should be held to the place where the vent of the core leads from. When the mould is very suddenly filled with metal, it tries the stability of the cores very much, and too great precaution can scarcely be taken to keep them in their places.

In casting marine engine cylinders it is the rule to fill the large core with sand, not for the purpose of strengthening the core, but only with the intention of having no hollow space for the gas to accumulate. Supposing no sand was put in the core, the probabilities are that the top of the mould might be blown off.

In casting sugar pans it is not customary to fill their cores with sand, however large they may be; they are cast hollow and the vent taken from them, in a manner that no other cores are done, that is, when they are cast convex up.

When the mould is dried and finished, ready for the metal, it is lowered into a pit or hole in the foundry floor, ready to receive it, a gutter or trench having been previously made where it is resting. A piece of fine sieve or wire-work is laid close to the edge of the plate on which the mould is built, the wire work covering the trench. A round or square piece of wood, three inches diameter and four or more feet in length, rests upon the sieve, which piece of wood is termed a "vent pin." The pit is then rammed up to the top, when the pin is withdrawn, and another piece of wire-work like the first is laid upon the hole that the vent-pin had made. This in turn is covered over with straw and sand four or five inches deep, and the vent is complete. This vent acts in the same manner as the celebrated "Davy lamp."

It is not only necessary that a moulder should know how and where to lead the vents from the cores and mould, but is is of vital importance that these vents should be secured from the metal. When metal finds its way into the vent or vents of a mould, the casting is seldom materially affected, it may be faulty, but in very rare cases is it a bad one.

Castings made with green sand are more liable to be faulty, when the vents of the mould get stopped with metal, than either dry sand or loam castings. Not so when metal blocks up the passage for the vent in a core, even of a very moderate size. The casting invariably is a bad one. The important part, then, of the moulder is seeing and knowing that the vents from his cores are properly secured ; that due provision has been made in the mould to get at these vents, so that they can be loamed all round the joint with wet loam, and then well rammed up with sand round the tube that conveys the gas from the cores to the outside of the mould. This is of essential moment to the moulder, and cannot be too much overrated, and should be particularly noticed in side vents, or vents taken from the under part of a core.

During the process of casting, moulders are busily engaged lighting the vents leading from the cores and mould; and this is quite essential, for two reasons—it encourages the gas to the mouth of the pipe, and prevents it from striking back upon the cores or mould.

In casting a large green sand mould, and when the mould is nearly filled with metal, a loud report is sometimes heard; gas has been gathering somewhere round the mould, and has suddenly fired or taken light. This is not good for a green sand mould, as it is liable to shake and start tender or weak parts of the mould, and thereby do mischief. To provide against that, shavings are profusely spread at intervals round the mould, and set on fire immediately before the cast, the gases then light when generated. This striking back of the vent is prevented, when casting hollow work, by the vent being made as already described in casting a pan.

Supposing no sieve or wire work to be used, merely an open vent from the bottom of the mould, and let a spark of metal come near the vent, an immediate blow-up of the whole mould, with all its cramps and bars, is liable to take place. If no light or spark goes near the vent, no harm will occur.

When we again dilate on moulding further on, occasion may be had to refer more fully to venting cores.

Venting moulds in green sand or dry sand is principally done with a steel wire from an eighth round to three-eighths or even half an inch, a small wire about twelve inches long, with a wood handle on it to protect the hand, and intended for ordinary castings. The thick wire, with a cross handle on it, is only used for the heaviest of green sand and dry sand. In ordinary-sized moulds, when the pattern has been rammed, and the top part that covers the pattern ready to be lifted off, the small wire is used freely, passing through the sand till the point touches the pattern. The top part being now lifted off, exposing the surface of the

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pattern, a ridge is made with the point of the trowel about three inches from the edge of the mould ; this ridge is made in order to connect all the vent wire holes that are about to be made into one channel, it becomes in reality an air passage or channel. The end of that channel must be carried out further than the top part covers ; the edges of the mould next the pattern are now freely swabbed with water, and the channel or air passage as well ; the vent-wire is then passed down as far as the pattern reaches, a space of two or three inches being kept between each little hole. Care has to be taken that no metal gets into that channel to fill those vent holes. Should the top part that covers the mould strain or lift the thickness of a tenth of an inch, the vents are choked. This would cause no visible eruption in casting, but it is liable to make the casting scabbed.

The heavy green and dry sand moulds are done in precisely the same way, only with a slight exception, that the job is all vented before the top part of the box is put on. When the pattern has been rammed up within three inches of the top, the large vent-wire is then (after a gutter or channel is made) passed freely down the sides, say six inches from the pattern ; when that has been done, a straw or hay rope is laid upon these holes, then a few clean riddled ashes, till you cannot see the rope. Three or four branches (or more, as the case may be) are led back from this main one, made in the same manner. Vent-pins, one and a half inches round, are put to those branches, and the finishing of the ramming up to the top of the pattern follows. In this way are these vents secured in the event of the top part straining.

Besides the top and sides of a green or dry sand mould, the bottom part also requires venting, and to attain this, much depends upon the shape and size of the pattern ; for instance, a square or round plate, three feet and one and a half

inches thick, requires the vent wire slightly bent, so that it may pass below it.

Castings that take the form of an H beam require to be carefully vented, to avoid scabs and a bad casting. If the pattern is light and easily handled, the part of the pattern that is to go for the bottom of the mould is filled with sand made sufficiently hard, and the vents made with a small wire. The pattern is carefully and quickly turned over on a bed to receive it, and when the pattern is ready to be drawn, the side vents are made and intended to communicate with the vents below. The top vents are easily made, as they pass straight through the top part to the pattern.

When the job is large, and the side vents cannot take the gas from the bottom of the mould, an ash or char bed is put into the hole made to receive the pattern, which bed should not be less than three inches deep, and three or four inches of sand should be between the pattern and the ash bed; four or more pipes, two or three inches diameter, are led from this bed to convey the gas from it; the vent-wire is used freely from the face of the mould down to the open bed, care being taken to close up the mouth of the vent-holes next the casting. This method of venting is always done in the early stage of the job being moulded, and when the bottom of the mould has only taken the impression of the pattern. It will thus be seen that enough has been said to shew how important the vent-wire is to a sand moulder, more especially in green sand. The vent-wire is an important tool; many jobs cast in dry sand would take no harm in not being vented, which would take serious harm in green sand. This occurs owing to the former being dried, which rather changes its nature, in becoming more porous as it were in itself, and the metal lies more kindly to the mould, especially if it be warm. The dry sand has another advantage, it is better able to resist a commotion of the metal when it takes place through an

insufficient venting, than the green sand is. If a green sand mould shew even very little irruption after being cast, either through the sand being a little too damp, or not properly vented, some part of the casting is sure to be faulty, and in many instances the cause of its rejection.

The green sand moulder, therefore, looks upon his vent-wire as something of *great importance.* The loam moulder, on the other hand, seldom or ever uses the vent wire, in fact, not at all when the loam is made of iron sand. When made from Erith sand, it is sometimes used for top parts of moulds, the Erith being so much closer than iron sand. The operator will then use straw and hay to vent his mould. Into all corners, up the sides of brackets, and blow flanges, the straw rope is used freely. Care must be taken not to have them too near the face of the mould, not less than an inch. If these straw ropes were within a quarter of an inch from the face the air might blow that part in, and thereby cause a scab on the casting. An inch gives sufficient strength to resist that taking place. When the loam mould is properly dried, the straw ropes are burned out, thus causing a space for gas, as the vent-wire does in the sand. When a loam mould is rammed all round with sand, loose straw is put to those vent holes, and led to a vent-pipe of two or three inches in diameter; and when cast without ramming up, as some founders do, the vent has free course to blow off. Those straw or hay ropes only apply to the sides of a mould, the bottom or bed being vented in the same manner as the green or dry sand, namely, with ashes, which are applied somewhat differently. Instead of a bed of three inches, the bricks are kept fully an inch apart, and the ashes fill up the space between, an inch of loam only intervening between the bricks and ashes from the casting; even two inches will do, but with any more than that the loam is liable to crack and cause trouble to the moulder, and is not good for the casting.

The vents of a loam mould being choked, from whatever cause, never cause an eruption, that is, are not visible to the moulder after being cast; a certain commotion must take place, but it is of so slight a nature that it has not power to move the heavy weight of metal above it. But the mould is liable to be faulty, as in the case of the green sand; neglecting or omitting to take the vent from those burnt straw ropes is infinitely worse than having no ropes at all; because by using ropes a vacuum is formed which becomes filled with gas, and if the proper road for its outlet is stopped, where will it go to? To the weakest part certainly, and that will be into the mould; to get there it must press a portion of the mould into the metal, and thereby cause a hollow in the casting. It would have been better in that case had there been no ropes at all; the mischief might not have been quite so bad.

Venting of loam moulds depends in a great measure on how they are built; and when we come to describe loam moulding the reader will see that this is the case. It should be borne in mind by the moulder, not to use straw ropes unless absolutely necessary, for two reasons; first, that they do harm when not attended to; second, it is a waste of time and material when they are not wanted.

SCABS AND SCALES—THEIR CAUSE AND EFFECTS.

A scab upon a casting, however fair it may be in other respects, is like an excrescence of the same name upon a human being, very unpleasant to look upon. The flanges of a casting may be straight and regular, snugs and belts perfection, and it may appear perfect, whilst the practised eye discerns a scab. A scab is not only unpleasant to look upon, but when it occurs in an important part of the casting

may be the means of its condemnation. There are three kinds of scabs with which castings are liable to be affected:—First, there is the raised scab; second, the hollow or dumb scab, sometimes called a buckle; third, and worst, one that combines the first and second.

Fig. 3.

Fig. 4.

Fig. 5.

The first, as it is here shewn, (No. 3 diagram) can be chipped or planed off, leaving nothing but a bright place to shew where it has been. These scabs may be caused (1) by the green sand, dry sand, or loam of the mould being too weak or too strong; (2) by the metal washing away some part or parts of the mould while being run in; (3) by the green sand being too damp, or the dry sand or loam not perfectly dry.

Although this scab can be chipped off, bored out, or planed off, still the portions of the mould washed off must have found their way to some other part of the casting, where they will form what is called "a dirty place"; and this dirt very often seems to find its way to an important part. This scab is made during the time that the mould is being filled with metal. It will be obvious to the reader from the above that though the scab of itself may be easily got rid of, the loose material floating about may be the means of causing a bad

casting. These scabs are never more than three-eighths of an inch thick, but may be of any extent in length and breadth. When only one or two appear on a casting, the running in of the metal has had something to do with it; but when the casting is a mass of scabs then the mould has been wet, or the material has been bad.

The second, or dumb scab, is of more serious consequence to a casting than the first, the form of it being shewn on No. 4 diagram.

It runs in all kinds of fantastic shapes, and is three-eighths and even sometimes half an inch deep. It will be seen at once how annoying this scab is when it occurs on the part of a casting that is to be planed or bored. Take a cylinder of any weight, from half a hundredweight up to thirty tons; if a few of these scabs are in the inside where it is bored out to fit the piston, and supposing them only to be one-quarter inch deep, the casting runs a risk of not passing. When they are three-eighths or half an inch deep the casting is almost sure to be spoiled, as it cannot be turned out. These dumb scabs are seldom found on green sand castings, but frequently in dry sand and loam, and loam cores in green sand. They will occur on any part of a casting, but seem to frequent more the round parts of a mould; of course that will be the hollow part of the casting. When they are on parts of a casting that are not to be planed or bored, it is difficult to know what to do with them; the casting, however, may not be any worse except in appearance.

The first cause of this dumb scab is the mould not being quite dry, or having absorbed moisture again, and a little steam being generated by the heat of the metal, close to the face of the mould, pressing a slight portion of it out before the metal is set. It seems, therefore, that the mould is filled with metal before these scabs are made.

The third kind of scab is a combination of the first and

second; it shews itself on a casting in the form marked on diagram No. 5.

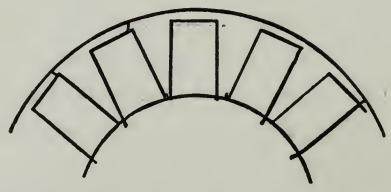
At the first look of this scab, it appears as if it was one of the first spoken of, and could be chipped off, but that is not the case. The edges have no hold of the casting, as you can enter the point of a thin chisel between the scab and the casting in many places; there is loam between the casting and the scab, and with two or three strokes of a hammer the major part of the scab will come off, shewing a dumb scab, with a thin portion of loam running completely through the metal. It will thus be obvious that when this kind of scab is found on a part of the metal which has to be planed or bored the casting will be rejected; and when it occurs where steam or water has to pass it stands a poor chance of passing unless it suits the engineer to mend it, which depends upon whether he is really a practical engineer; if not, as is too often the case, the casting will be condemned.

The same cause, in this case, but greater in degree, has been at work in causing this, the *worst of all scabs*, as occasioned the dumb scab. The generated steam has had power to press that portion of the mould opposite to it right through the thickness of the metal, which portion thus forced off never exceeds $\frac{3}{16}$ths of an inch in thickness; in fact, it requires the blade of a knife to scrape the loam out. This displaced portion of the mould seems to get wedged in, as it were, between the outside and inside of the mould, and it remains there. This takes place more frequently with Erith loam, or dry sand, than with iron sand loam. This kind of scab does not occur often, but, knowing that it happens at times, it is well to speak of it. Seeing that the dumb scab, or buckle, is the most prevalent in casting, we cannot pass without saying something further about the causes of it.

We have said already that those kind of scabs are most seen on the hollow parts of a casting; for example, on the

inside of cylinders. Even when the mould is quite dry, and the material composing it good, if the core is a small one, say four feet diameter, and whole instead of half bricks have been used in building it, this core will be very liable to form dumb scabs. The joints of the bricks not being equal, a great body of loam gets next the face of the mould between those parts, and contains the most gas, which will escape by the easiest place, and that is the face of the core; in doing so part of the core may be forced out. Again, dumb scabs may be caused by the loam being too strong and clayey; if this is the case, large cracks will occur all over the mould, and if they are not properly filled up, dumb scabs may be the result; more especially will this take place on the bed of a mould, because, the mouth of the crack only being stopped, the gas rushes from the bed, and forces the filling up of the crack into the metal; and, should the mould be damp, the steam will co-operate with the gas, and in this way cause no small damage to the casting. It would be better that the cracks were not filled up than that it should be done imperfectly. This applies to loam moulds only, for green and dry sand never crack.

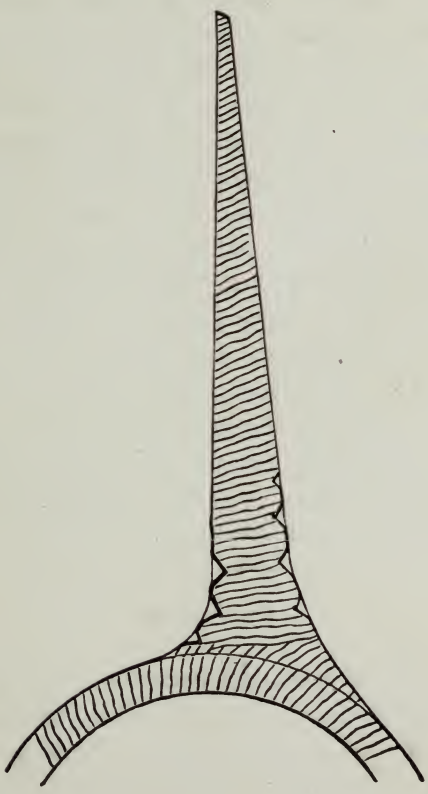
Fig. 6.



As wide joints next the face of a mould in loam (shewn in Figure 6,) are dangerous, this evil has to be carefully avoided in propellers, which are castings very liable to dumb scabs, especially at the curve close to the boss, the chief reason being that there is often too great a body of loam at that

particular place. In drying the mould steam gathers between the bricks and the loam causing a slight space; and when the mould is filled with metal, the space fills with gas, which forces the loam (as has been said already) into the metal, thereby causing those indentations shewn on the propeller blade, Figure No. 7.

Fig. 7.



One word more about dumb scabs. Air or gas not getting away from the face of a mould into its proper channel may cause scabs, but dampness is sure to do it, and if both of these

combine a very poor casting is the result, more especially when the mould is cold.

All persons who have had much to do with castings will have noticed in some which have been cast in loam that dark lines are all over the body of them in every conceivable shape, a perfect map in fact. If these dark lines are examined closely they will be found to be slightly hollow. The moulder gives them the name of "veins," so called, we presume, from their resemblance in form to those of the human body. These veins are caused by the cracks that have been in the mould. Every vein has been a crack in the loam, too small to be stopped up with it. The mouths of these cracks get filled up with blacking, and the air presses it into the metal, producing thereby dumb scabs in lines. These veins occur most frequently on the sides of a casting; they are seldom if ever next the bed, owing to the blacking being able to run to the bottom of the cracks, filling them up; besides, there is a greater pressure of metal on the bottom or bed of a mould than on the sides. The loam, when veins occur, has been *rather strong or thick* on the face of the bricks. No dry or green sand castings are veined. No casting is ever condemned for being veined, but it does not *look well*, and would certainly not be fit for an exhibition.

SCALES

Are mostly found on loam, and sometimes on dry sand castings, but never on green sand. The blacking, and the way it is put on, is the sole cause of *scales*. Blacking, to be *good*, is made from oak charcoal, ground to powder as fine as flour. A few years ago, some blacking makers introduced into their blacking less expensive wood than oak, the result being very unsatisfactory to moulders, owing to scales on their castings, as, the wood being of a light nature, the charcoal did not

adhere to the mould. This adulteration gave rise to much dissatisfaction, resulting in a patent blacking being invented, which has not been in use many years. It is composed of an article, being almost pure mineral carbon, which we understand is made from shale out of gas retorts. It suits well, as scales with this blacking seldom occur, unless when the clay water is very weak, or carelessly put upon the mould. This blacking is put into water which has been highly coloured with common clay, the clay being for the purpose of causing the blacking to adhere to the surface of the mould. Blacking is put into the water until it attains the consistency of thick paint. The clay water must not be too weak, as scales on the casting may be the result; besides, in this case, it is easily brushed off the mould when dry. Neither must the water be too strong, as the blacking, after becoming dry, cracks all over the mould, and is inclined to peel off in many places like a skin, and scales are sure to occur.

The blacking is put on with a common paint brush, or (as in the case of dry sand) with a swab. It is laid on ordinary castings until the mould has a coat equal to the thickness of heavy paper; but where the metal is very heavy, it is all the better with a thicker coating. Care should be taken in blacking a mould not to put on too much at a time, and not to come over the joinings of the blacking, and it should not be applied when the mould is very hot.

Scales are troublesome to the cleaner, as, being so thin, they are not easily chipped off; and when they are chipped off, the casting has any thing but a nice appearance.

In some foundries all the moulds are sleeked with tools for the purpose during the process of blacking, and scales will be caused through sleeking too hard, or continuing the sleeking after the blacking is nearly dried on, which is done by the moulder for the purpose of trying to make his casting look nice and have a smooth skin. Too hard sleeking is apt to

slacken the hold of the blacking, especially when the mould is very dry, or a little warm.

The patent blacking has a great advantage over *the best* charcoal, as it is scarcely ever burnt off by the flame catching the mould at the time of drying, which was no unusual thing when the charcoal blacking was in use, when it would have to be blackened over again.

COLD SHOT CASTINGS

Are produced by three causes. (1) The mould being filled too slowly. (2) The metal being too dull to suit the kind of casting required. (3) The metal being poor. Cold shot is another word for a bad weld—a refusal of the metal to amalgamate at the place of meeting in the mould. The green sand moulder has more reason to fear this than the dry sand or loam moulder. His mould being cold and damp, if the metal is admitted too slowly it will rise lazily up the sides, getting thicker until it comes to the place of meeting, where it will fail to join, as shewn in the section of a column or pipe, Figure No. 8.

Fig. 8.

We are supposing the pipe to be cast horizontally, and the metal to be admitted at the end of the mould, as many are run in this way. A pipe of this kind for either steam or water would be of no use, and a column to support any weight would be very much weaker, than if sound on the top.

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Too dull metal, even when run into the mould with proper speed, will shew exactly the same fault.

Poor iron—pig iron of inferior brands mixed with dirty hard scrap, possibly some of it burnt, old fire bars, &c., will bring metal out of the cupola with *no life*. Be it *ever so hot*, it will not run, it seems dead, and has scum or skin on the top of it like stagnant water. Whatever mould this metal is put into, unless put in very quickly, or the casting is of an unusual thickness, it will produce a casting that is liable to be cold shot. Even a difficulty is found in getting common furnace bars to run with metal of this description.

Sulphur, silicon, manganese, and other impurities, are found in the best of metal, but in this poor iron they seem to be present in a greater degree, causing this skin and preventing amalgamation. In boiler plates something like this is sometimes found, which is termed "lamination."

MENDING OR BURNING CASTINGS.

When any part of a casting has been broken off, such as a flange or a snug, or a blown hole has appeared, the moulder considers whether he can mend this without injuring the casting. Mending, so as to insure success, will depend wholly upon what part of the casting requires it. The formation of the casting has also to be considered, as well as the kind of metal that has been used; and herein lies the danger of burning or mending. It is not every casting that will stand a portion of it being brought to a melting heat without splitting in some adjacent part; it depends almost wholly upon the formation of the casting.

Mending at the extremities of a casting of almost any shape is generally safe, but at the middle parts seldom a success. In our opinion, mending a casting by burning a piece on should never be resorted to, unless it cannot be mended otherwise,

as it is often a forlorn hope. When the casting is a bad one, owing to a fracture, blown part, &c., it cannot be made worse by burning, which may as well be resorted to. Burning or mending a casting can only be done once on the same place; hence the necessity of taking every precaution before beginning.

When a casting has been broken, and mending the part resolved on, it is best to use the piece broken off when it can be had, and if it cannot, then one exactly the same pattern should be cast.

The broken piece being laid to the casting in its place, pieces of dried loam (called cakes) are then fitted about the part, leaving about half an inch of space all along the fracture exposed; these cakes to be two or three inches higher than the broken part, so that all the dirt and scum may float to the top, and clear of the fracture. Cakes of loam are also made to cover the bottom part, to prevent the metal from running right through during the mending. The broken part should then be surrounded with a fire until it becomes red hot, the dried loam cakes being removed before the fire is applied.

The portion of the casting to be mended, as well as the piece to be burned on, being now red hot—good *hot* metal in readiness—the fire smartly taken away—the loam cakes and the broken part put back in their proper places—pieces of iron ready at hand to secure them there,—the metal is then run along the fracture until the casting and broken piece are thoroughly fused together. This will be easily known by travelling the point of a quarter or three-eighths iron rod between the two. When the point of the rod touches the bottom cake of dried loam, and nothing is felt but liquid iron, the mend is complete.

Many castings stand the fire, but give way during the time the metal is being poured on the fracture. After the mend

has quite set, it should be covered over with hot metal, and not again touched until the whole is quite cold. The hot metal used to cover it is generally that which was used in the mending, broken into suitable pieces.

Again, some castings rend in the cooling. The softest of iron No. 1 should be used for a fracture, as it does not produce the greasy scum which comes from No. 3, and it also penetrates quicker into the fracture, and is much easier chipped.

The importance of mending a broken casting when red hot is obvious, as it requires less metal to be poured on the break than if the parts were black. Moreover, when the parts are black, the metal when poured seems to glide off, as if the broken part had been oiled or greased. The oil and tar from the coal cause this to be the case; and when the fire is made with gas coke, the sulphur from it also produces the same effect.

The metal for burning should be all in one ladle, it does not answer when a second has to be used, as the mend is *sure to be dirty;* the refuse or "slag," as it is commonly termed, from the last of the first ladle being liable to lodge in some part of the half-mended fracture.

When a large casting has to be mended, it is best to put it the night previous into the stove, which should be cold when it is first put in, then fire well up till the next day. When it is taken out of the stove, put the fire at once on the place to be mended, and when that is done lose no time in returning it back again to the hot stove. In this way the whole casting expands gradually, and, cooling down with the stove, it contracts slowly.

When a casting has been imperfectly mended, and has been done again, it will be liable to crack two or three inches from the fracture, the reason of this being that the metal two inches back from the fracture has lost all its elasticity, in

short it is calcined—it has become like the top or rather middle part of a furnace bar that has long been in use. The two inches of the casting next the fracture are dead; and even should the second mend be a complete weld, if that part is struck lightly with a hammer it will be very liable to break two or three inches from the original fracture; hence, if a mend is not properly done on the first trial, you *cannot go back to it again with success*. The best thing to be done on a second burn being resolved on is to cut three inches off next the fracture, and in this way you come to good metal again.

It may be fairly questioned—Is a burn as good as if the casting had never been burnt? We at once answer, (assuming the mend has been properly done, and there are no symptoms of a crack on any part of the casting,) it is equally as good as if no burn had taken place. For example, we have known the tooth of a spur-wheel burned on to stand, while some of the others gave way. Again, we have burned a large piece on propeller blades, which have come back to us again broken on the same blade, but never near the burn. Therefore, from carefully watching the results of mending castings, our impression is that the mend when properly done is equal in strength to the rest of the casting.

It may again be asked—Would the burning have an evil tendency on any other part of the casting, even a considerable distance from the mend, and thus when the working strain is put upon the casting cause that part to give way? In answer, we would say that it may and even does take place in castings of a certain structure, such as bed-plates, condensers, cylinders, girders, &c., where it is difficult to determine on what part of the casting an undue strain may take place, owing to a portion of it being made to a melting heat, cast iron being of such a nature that it may be on the point of flying and *no one be aware of it;* but in plain castings, (and

especially when the mend is at the extremities,) we scarcely think that burning has any vital effect upon the other parts.

When a mould has been cast, and an irruption takes place, *however slight*, if the moulder is sure that metal has been vomited out, it is well to take the top part of the mould off to see the casting. The hollow blown places can then be quickly and safely burned, the casting being in a bright red state. Sometimes a mould will blow and vomit metal out for a considerable time, and then after it has relieved itself of the gases it will take back quietly all the required metal, in which case the casting is seldom blown. In other cases a mould will blow violently for some time, and as far as can be seen not take any metal back, and, on the top part being taken off will shew no symptoms of requiring to be burned; but when this does occur the soft parts of the casting are found out when it is too late to burn it, and most likely on parts where it would be foolish and impracticable to try it.

Blisters or shells on a casting are easily mended when they appear after being recently cast. They are generally to be found on green-sand castings, and are caused through hard ramming of the top part, and the want of the free use of the vent-wire. They are seldom above a quarter of an inch deep, two or three inches in length, and an inch broad, and very often castings are condemned on account of their presence.

RAMMING GREEN SAND OR DRY SAND.

Not a great deal can be said upon the above. Both kinds of sand are rammed nearly in the same manner. Two kinds of rammers are used for both green sand and dry sand, one being called a small or pin rammer, the other a dog or flat rammer. The first is wholly made of iron rod, three quarters of an inch round and four and a half or five feet in length, with a flat part at the end two and a half inches broad, and

the same thickness as the rod. To be able to handle this rammer properly is of great importance to the sand moulder; it is to him what the hammer is to the smith, or the hammer and chisel to the engineer. This rammer is used for ramming the sand that lies close to the pattern, which is termed small or pin ramming.

The flat or dog rammer is used for the intervening space between the small ramming and the firm ground. It is a rod of iron exactly the same as the pin rammer, with the exception that on the point of the rod is cast a piece of flat iron, 5 in. × 3½ in. × 1 inch; hence its name. For pits and places where much ramming is required, wood is substituted instead of the three-quarter-inch rod iron, and is inserted into a wrought iron socket, the point being a round or flat piece of cast iron.

Ramming wholly depends upon the nature of the work the moulder may be employed upon. Light castings, such as grate metal, balcony railings, balustrades, &c., require quite different ramming from those of heavy green sand, so much, indeed, that a light green sand moulder makes but a very indifferent hand at heavy work, and *vice versâ*, the great obstacle being the different amount of ramming required. We may say here that there is no defined rule for ramming, the experience of the moulder in the class of work being his only guide. Therefore, the question may be asked—Is ramming a rule of thumb business? We answer, No. It is true that some jobs will stand more ramming than is absolutely needful without doing harm, more especially in dry sand; but in the majority of cases it is not so with green sand. Any casting rammed too hard is liable to be scabbed, and if *very hard*, it will cause the metal not to stay in the mould; besides, great difficulty would be experienced in drawing the pattern. The ramming of a mould, then, is judged by experience. The lower parts of a mould are made considerably

harder than those near the top, owing to the pressure of metal being greater at the bottom. A mould should be *firm*, nothing more, and care should be taken not to strike the pattern in ramming, which is liable to produce a scab, as it causes the sand to be *too close* on the face of the mould, and prevents the gas from passing into the openings made by the vent wire. Again, a mould may be rammed rather soft; in which case, especially if there is a deep flange, or deep parts in the mould, the deep parts are sure to be swelled or strained, and are made perhaps half an inch thicker than they should be, besides being irregular and out of shape. A part or parts of a mould not properly rammed is sure to turn out an ugly casting, besides causing a deal of extra work after the pattern is drawn. The moulder may try to rectify it to some extent by firming up the soft places, but it rarely succeeds in being so well done as when the mould is properly rammed when the pattern is in the sand.

Dry sand will stand much more ramming than green sand, and can always be made much firmer, the reason of this being that the drying of the mould has an opening effect on the sand, causing it to become more free in the pores by the exclusion of the moisture. If a dry sand mould be filled when it is not dry, or only *partially* so, the metal would most certainly not stay in the mould, and this would be wholly due to the closeness of the mould. But the drying (for the reason mentioned) produces an openness in the sand which allows the gases to pass freely to the vents, and the metal lies quietly and kindly in the mould. Thus great freedom can be used in ramming dry sand, which cannot be made too hard, that is, of course, compatibly with the drawing out of the pattern.

With green sand the same liberty cannot be taken without causing bad results. Should the top part of a mould that has a plain flat surface be too hard rammed, and not extra well vented, the casting will present an appearance of being cold

shot, and in some instances will be blistered, although the metal was in good condition.

We may close this part on ramming with the moulder's motto—Ram well, but vent well, as the venting is an *antidote* to a mould *too hard rammed*.

HINTS ON PATTERNS.

A properly-made pattern is of vital importance to the moulder, and not only to him, but to the parties who have to do with the casting after it leaves the moulder's hands. A casting that is the exact shape and form of the pattern will give less trouble to those who have to work with it than when it has to a certain extent lost its shape and form. And how is this to be attained? Simply by making the pattern so that it may freely leave the sand. In jobbing foundries too little attention is paid to this object, hence the pattern suffers by the moulder having to rap it severely to slacken its hold of the sand. A pattern has often been broken to pieces in drawing it out of the mould, and a stranger to look at it might allege downright carelessness on the part of the moulder; but in every case he is not to blame. The pattern must be started in the sand before trying to draw it; and if proper provision has not been made by the pattern maker in the shape of places set apart for rapping and a certain amount of taper, also made of seasoned wood, the pattern will be sure to suffer, and the mould also.

In foundries where certain classes of work are done by machinery, such as sewing machine castings, railway chairs, telegraph posts, mill machinery, &c., all the patterns are got up regardless of expense. And why? Because the pattern must leave the sand without a grain being disturbed, and without it being started before being drawn. Nothing less would do. Balcony railings, balustrades, fancy gate

work, grate metals, &c., must also leave the sand perfectly undisturbed.

It might be said here that such a class of work is quite different from jobbing work, and that it would not pay to get up jobbing patterns like the class just mentioned; but it would be just as easy to get up patterns to mould right by as it is to make them so that they are a trouble to the moulder.

In some foundries great trouble and expense are experienced through ill got-up patterns, the pattern shop going upon the principle of economy in their department, which is quite commendable so long as it does not cause undue expense in the foundry; otherwise the principle becomes very reprehensible.

A pattern maker should have some knowledge of moulding, which is indispensable on his part; and so long as he keeps that knowledge subservient to the moulder all goes well; but when he thinks he knows more than the moulder, *which too often happens*, work between the two does not go smoothly. They are closely allied in their work, and, such being the case, it becomes them to work to each other's hands as much as possible. The pattern maker can save the moulder a great deal of trouble by very little exertion on his part, and so with the moulder. It becomes them, therefore, to give and take, *neither* to be too exacting. Should one know every thing, and act upon the principle that the other knows little or nothing, no good can ever come of it, as the ignored one is sure to suffer through working at a disadvantage.

The pattern maker should be often in the foundry, as it is there he will gain experience, and will see that all castings do not contract one-tenth of an inch to the foot, as he was taught at the bench. The amount of contraction will in a great measure be according to the shape and form of the casting.

Again, loam castings, as a rule, do not contract so much as

sand castings, partly owing to the material that the loam mould is composed of offering a greater resistance to contraction than that which sand offers, and partly because all loam moulds yield a little to the mould expanding after being just filled. In large loam castings this occurs to a greater extent than in small or light loam work.

The pattern maker by being often in the foundry will see how his work comes out of the sand, and will be able to avail himself of any suggestions that the moulder may have to offer for their mutual benefit and the interest of their employer, and in this way hard work will be made easy.

The moulder on his part should take great care of his pattern, and nothing is more conducive to that than the knowledge that his pattern is well made for moulding. Patterns that are intended to be moulded in loam should be made of as little wood as possible, compatibly with sufficient strength. The pattern maker should consult the moulder before he begins to make his pattern as to which way it would be best to mould it, and on both coming to an understanding much trouble will be avoided. The moulder in this way becomes conversant with what the different parts of the casting are supposed to do according to the designer's idea.

We will close these hints on patterns for the present, as we may have to refer to them again in describing the three branches of moulding. Sufficient has been said to enable the reader to understand how essential it is for the moulder and the pattern maker to work together.

RUNNING METAL INTO MOULDS, AND THE USE OF FLO'ERS OR GATES.

We cannot think of a more important question to the moulder after venting than—How will you run that casting ? And after that question is answered there is another—What

size of runners, and how many do you propose ? From the smallest sheave of one pound weight, or a fancy little ornament, up to a casting of sixty tons, the choice of a place for running the metal in is of *great importance.*

A light job in green sand, or a heavy one in green sand or loam, may be all that a first-class moulder could desire. and yet the casting may be spoiled through being run badly; and this is done (1) by running too quickly, (2) too slowly, and (3) by not running in the right place or places, as we learnt from running a little fancy ornament or sheave when we were apprentices ; and also in running a sixty-ton casting the same principle is involved. The choice of a place or places to run in the metal will wholly depend upon the formation or shape of the mould. Suppose we take a fancy ornament, we examine it for the strongest place and one where no obstruction is offered to the metal running into the mould. The system of ways or gates is generally adopted, and made by joining four or five sprays or small runners from the main one. These little branches should be opposite a slight space in the mould, so that the metal has free course to pass all over. The more sprays that are cut from the main runner the less size they will need to be, and are of course easier broken off the casting. A fruit plate could not be run in this way, as the edges of the casting are so thin and frail that no runner could be attached to them without a great risk of breaking the casting in taking the sprays off ; hence a fruit plate is run by the centre, because there is a flat round space. Sometimes a flat and sometimes a round runner is used, and one is as good as the other. In this way the metal has free course to spread all over the intricacies of the mould. Balcony railings are generally run with three and sometimes four main runners, each having upwards of twelve little sprays, as in the case of the small ornament. Balustrades are generally run from the plain end or stalk. Water-runs

for houses are run from the top, the convex part being cast up, and the runners (there are two) are about ten inches in length and only a quarter of an inch wide at the joint, tapering to three inches at the opening. This is what is termed a plump runner or gate, so called because the metal from the ladle falls or plumps at once into the mould. The castings could not be run at the edge, being so thin. Pots and kettles are cast exactly the same way, the runner only being much shorter, say three inches. These runners are made wide at the top, so as to enable the moulder to throw in the metal at once. This class of work is a speciality, and a good moulder at any other class of work would be very imperfect at water-runs, pots, and kettles. Grate metal is all run from the edge, with a great many sprays leading from the main runner, care being taken to make these sprays half the thickness of the casting, and in this way they are easily broken off. A sheave presenting a thin edge all round can be cast no other way than by a plump gate or runner. It is placed at the side of the core in the centre, and a round pin of wood is rammed up in the top part of the mould, thus forming the runner.

Again, bevelled pinion wheels are run at the centre, and not from the top, the metal being admitted through what is called a worm-gate. The object in running a casting like this in such a manner is to prevent the tender teeth from being washed away by the metal, as would most certainly be the case in a green sand mould were the metal admitted from the top, as in the sheave. All small pinions of a fine pitch are generally run in this manner; but when the moulder has no worm-runner he is obliged to run the metal from the top, in which case the mould should be slightly dried to harden the teeth, and in this way it enables the mould to stand the metal better. If only one casting is wanted he should mould two, as the risk is too great to depend upon one cast in this

manner turning out perfect. From these few modes of running small castings, it will be at once seen that everything depends upon the shape of the casting wanted as to how and where the metal should be admitted.

Ordinary sand work is generally run by the lowest place in the mould, unless in the case of pipes, columns, &c. A column that has a top and base to be turned and polished should be run in the centre of the casting, the metal just clearing the sides of the core. The end or base of the column presents at the first glance a better place to run it by, and in fact so it is when the skin of the base is not to be broken. Some moulders may think this strange, but a column run in the centre will give a clean base and top, and when run by any end will be dirty. The reason may be asked—Why is it so? We would say that the motion of the metal caused by the runners playing down the base produces a kind of scum faintly mixed with slag, and the good metal flowing underneath fills the other parts of the mould. This impurity rises until it touches the top, where it remains. Nothing will be seen on the rough casting to indicate any impurity, but the latter will be seen on the skin being broken, more especially if the metal used is dirty, and columns are often cast with anything but good clean metal.

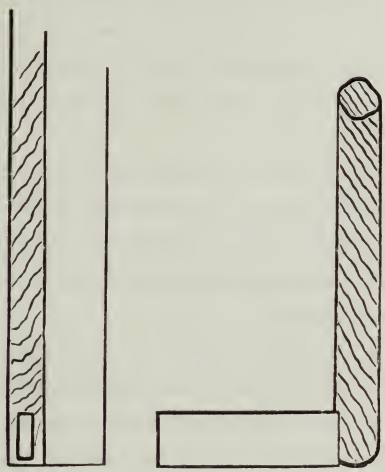
The question may here be very fairly put—Does no scum or slight slag gather in the centre of the column when run there, to cause a weakness in the casting? We would say not at all, as there is no place to retain any impurity, such as the base or the top of the column offers. It is continually getting away, and consequently cannot gather as it does in the base when run there. Were the column to be turned all over round the locality of the gates it might be found slightly dirty when the skin was broken, but no good moulder would cast a column horizontally that had to be turned all over. Our business at present, however, is with columns for ordinary

purposes; they may be cast horizontally, and the best way is to run them at the centre, taking special care that the metal does not strike the core, or scabs may be made. It is safe and sure, with heavy green sand, to run at the lowest part of the mould, because in this way the metal rises quietly and kindly all over the mould, and thus in a great measure prevents scabs. The number and size of the runners wholly depend upon the job to be cast; for instance, a machine bed of the heaviest kind for planing may be cast with four runners, two at each end. Another kind of casting, not a third of the weight, may require six runners. The heavy machine bed can admit with safety two large runners at each end, while the other job perhaps could not be done with any other than small ones, hence the need for more of them. The size of each runner depends upon the thickness of metal it is attached to.

When a mould is run from the bottom the runners require to be much larger than when it is run from the top. Moulders sometimes make the mistake of furnishing a mould to be run from the bottom with the same sized gates as would be used if it were run in the ordinary way. The bottom runner or runners should be one quarter larger than when the casting is run from the top, seeing that they have to press the whole weight of the casting up when the mould is about filled. A mould so cast will take the metal from the ladle at first with great speed, but as it fills it will gradually take it slower and slower, until when just about full the moulder will find that it is comparatively slow. Green sand castings of a few hundredweight may be and are run from the top with safety, as the metal has not far to fall, but castings from ten hundredweight up to five or six tons should be run from the bottom, that is, the lowest part, care being taken to have the runners thinner than the thickness of the metal, as they are less liable to scab the mould when the metal is rushing in, and prevent the edges of the casting from getting broken in separating the gates from it.

Figure 9 shews us exactly the formation of the bottom gate. The vertical gate must be at a sufficient distance from the mould to enable a strong body of sand to intervene between them. Many castings have been lost owing to the pressure of the metal in the upright gate forcing in the sand upon the mould. Eighteen inches are sufficient when the sand is well supported with irons.

Fig. 9.



It may be here asked—How do you get these runners out before the metal is admitted ? The reply is simple : After the pattern has been drawn, and when the mould is finished, the square or rectangular-shaped one is drawn to the inside of the mould, and the upright round one drawn upwards, both being tapered to suit.

When a dry-sand mould is made with rotten rock and dried loam, it can be run with comparative safety from the top, especially when the mould has been thoroughly dried, the nature of the material being well adapted to resist the fall of

the metal upon the bottom or surface of the mould. We say "with comparative safety," but in order to make the operation perfectly safe it is better that the mould should be warm.

A dry-sand mould made with Erith sand is very different. In this case, when the cast is run from the top and the mould is cold it is invariably scabbed; and when a moulder knows that he cannot close his piece of work during the time that the heat is retained in the mould, he should make provision to admit the metal at the bottom of the mould.

When a mould is made of the last-described material, and can be cast when the mould is hot, it can then with perfect safety be run from the top, and the metal may fall any height.

This sand seems to have a particular propensity to contract damp after becoming cold. Every dried mould does so to a certain extent, but this sand in particular becomes cold sooner, and absorbs the damp more quickly, than any other dried sand of which we know.

Loam castings, or, as we might say, castings made in loam, are invariably run from the top, except in special cases, and these cases occur when the metal cannot reach or fall upon the bottom of the mould as soon as it leaves the ladle. Some part of the mould forming a projection, the metal falls upon this first, continually playing upon it until the under part of the projection is filled. The best made loam, even though of the best material, would be very liable to scab were the gates leading the metal to fall upon a projection of the mould, more especially if the mould were cold when the metal was admitted.

The greatest number of loam moulds are run from the top. Three reasons seem to establish the superiority of this method over others. First, it can be performed with safety when no part of the mould intervenes between where the metal is

admitted at the inlet or gate and the bottom of the mould; second, it is better for any casting when the mould is run from the top, since the highest parts of the casting are filled with hotter and better iron than when the molten metal is run from or at the bottom; this of itself is calculated to give the casting a sounder top than it would otherwise have; and third, the moulder can collect all his runners or gates more compactly when he is forming his large gutter (commonly termed "head") with sand, previous to casting, than he possibly could have done had the casting been run from the bottom.

Sometimes it happens in loam moulding that the formation of the casting to be made will not admit of gates or runners from the top being used in sufficient numbers or size to fill the mould in proper time, or there may be no direct and clear way for the metal to reach the bottom. When a case like this occurs the metal is run in at the bottom, possibly with the assistance of a few gates at the top.

Propellers are better castings when run as high up as possible on the boss. The top of the blades thus gets hotter metal, rendering the edges clean and sharp. This is seldom the case when the metal is admitted at or near the bottom of the boss.

Cylinders require, more than any other loam castings, to be run at the top, as this plan has the effect of giving the casting a clean bore. The gates or runners should be all round the barrel, the distance between each pair not exceeding eighteen inches. Care must be taken to see that the metal clears the outside and inside of the mould.

In casting very large moulds the moulder should take care to have his running gates properly distributed for the good of the casting, and yet not too scattered, as they have all to be connected in a large gutter, and when they are needlessly scattered in arrangement it will necessarily cause more metal

to be melted than is absolutely required, and really do no good to the casting, while it will cause the workmen to have extra labour in breaking up the heads.

A loam mould run at the top *may* scab, but it only occurs when the material is bad, or has not been properly dried. Loam too weak, too strong, or too muddy, is termed bad, and when not properly dried it is either burnt, or retains a suspicion of moisture. When a mould is in either of these states it will scab, no matter where it may have had the metal admitted. Erith loam when burnt is much safer than iron-sand loam.

THE MOULD FILLED TOO SLOWLY.

When the moulder has decided on the place or places at which to run his casting, his next care is to see that his runners or gates are adequate in size and number to fill the mould in proper time, so as to insure a sound casting. When he is moulding an ornament, say a fruit plate, and makes his little sprays or runners from the main gate too small, or too few, his work will be a failure. There will be a want in the fruit plate here and there, the metal having been so slowly admitted has been "dead" at different places of the mould, refusing to travel—or rather not being able to travel—through the little veins or channels in the sand. The same thing happens with moulds for a balcony, balustrade, pot, kettle, and water-run; the failure occurring even when the metal is of the finest quality, and as hot as the furnace can make it. Castings of an ordinary size in green-sand suffer much when cast too slowly, no matter what their shape or form may be. Some, of course, will suffer more than others, such as spur wheels, pulleys, lamp-posts, &c. Over-slowness is also very injurious to heavy work done in green sand, if it will not altogether, in many instances, be the means of practically destroying the cast.

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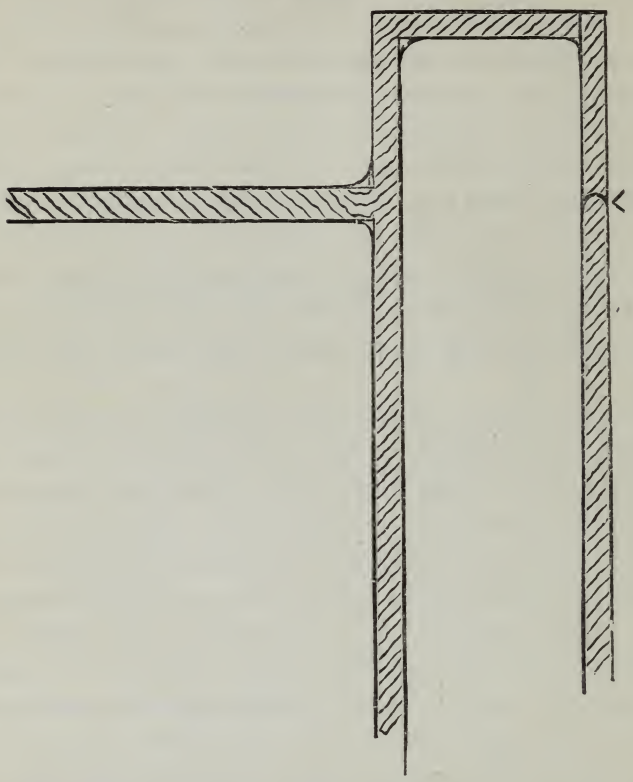
When the mould has a large surface, and that on the top, and the surface is exposed too long to the great heat of the metal during the slow process of filling the mould, there is danger of a portion of the top part being drawn down; and even when the top part does stand good the casting on the top will have an ugly appearance; the edges will be round and full of dirt; cold shot will prevail all over the casting; and the latter will have but little chance of being looked upon as worthy of the name. In the case of a loam mould which has retained some of its heat, but in which the casting has been done too slowly, the casting does not suffer to the same extent as in the case of a sand mould, the reason being that owing to the warmth of the mould the metal retains its lively condition much longer than it does in the cold green-sand.

A loam casting, in order to shew cold shot, must have been cast very slowly indeed, or the metal must have been very inferior and dull whilst in the ladle. The parts where it is most likely to be faulty, for a large loam casting, will be in the different webs or plates that may intervene between the bottom and the top of the mould, and in some places where it may not be easy to see it, especially where there are chaplets. The metal rolls lazily up the sides of the mould, carrying along with it dust and particles from the mould, until it reaches the top of the first core, over which it slowly flows, and meeting in the centre, possibly no amalgamation is formed at the proper place of juncture, or if it does, the amalgamation is only a very imperfect one.

When chaplets are in a web of metal the metal will not close so keenly and completely round them as it ought to do. Water or steam may pass between the chaplets and the metal, and in this way the mould is filled until the metal reaches the top. The casting thus produced may not present a very faulty appearance on the top, but other parts of it will

probably be much less satisfactory than its superficial area. Take for example a casting of the form of

Fig. 10.



Supposing the moulder to have made his gates or runners too small, and to have placed no runner on the highest part, the metal at the same time being rather dull. In this case the part marked < on the figure would be apt to shew what at first sight would seem to be a crack, but which, on closer inspection, would be seen to be—*not* a crack, but—cold shot. The reason would be that the metal had slightly paused at this point in its upward progress during the time

the plate was getting filled, the slight stoppage being enough to produce a strong film or skin at that particular place, and thus cause a parting, as it were, between it and the metal above. Had a runner been here to keep the metal in agitation during the filling of the plate no harm would probably have supervened.

This illustration may help the reader to comprehend how important it is to have the runners from the top and properly distributed over the mould, as he may not always be sure of getting hot iron to cast with, even apart from the contingency of his mould having been run too slowly. A propeller is sure to have an ugly look when it has not been properly filled, the top edges of the blades appearing as if rats had been eating them. A casting of this kind might likely be condemned when the metal is not run with proper speed into the mould. A piston (when large) which has been cast too slowly presents an ugly appearance on the top of the casting, so that engineers do not care about having it. The casting seems so unsound and ill-looking that they believe the steam would very soon make a serious impression upon it. Such would very probably be the case, as the casting would not possess a hard skin, and would be wanting in that essential element requisite to give it the sound surface so much needed in a piston.

A cylinder cast too slowly with ordinary hot iron would be very apt to be defective in the bore, especially if the metal was not clean. The casting otherwise may appear first-class, or it may shew threatening signs of cold shot on the top, but not enough to call attention to the fault. If the metal be *very* hot, and at the same time clean, these qualities may save the casting, even when the latter is produced slowly. But very hot iron is not the rule in large castings, and we should therefore say that the cylinder which has been cast too slowly has a slender chance of turning out a clean bore.

Dry sand castings fall under the same remarks as loam as regards filling the moulds too slowly.

THE MOULD FILLED TOO QUICKLY.

This is an evil that the moulder should guard against equally as much as against undue tardiness, since serious consequences are apt to attend it as well as the other. There are perhaps a few castings which may be excepted from this observation, that is, they can scarcely be filled too quickly. We refer to such castings as those of runs for houses, pots, pans, and several other castings connected with sanitary purposes. These being so thin the metal has almost to be (as it were) thrown into the mould, the moulding boxes being properly secured so that no straining of the casting may take place. In casting ornamental work, when the metal is rushed in too quickly, in some instances the box may yield, and slight fins of metal will be formed on the outer edges of the casting, while the casting is webbed all over where the spaces should be. In such cases the casting is said to be "strained," through the runners being too large. When the box does not yield to the undue forcing in of the metal the casting will be liable to get broken in the process of detaching the runners.

We may here mention, before going further, that the terms "gate" and "runner" are not at all times synonymous. A gate (strictly speaking) conveys its own meaning, that is, an entrance. The runners are supposed to be branches made to lead all over from the gate; but moulders frequently confound the one term with the other, or ignore one or the other by using the term gate or runner indifferently. For the future, then, we shall speak of the gate as the entrance, the place where the metal enters first, and the runners as merely connecting the casting or mould with the gate.

All kinds of ornamental and grate metal are cast much more quickly than ordinary green-sand work, but it is quite possible to over-do it, and for the casting to become slightly strained, causing a deal of extra work to the dressers in chipping and filing off the fins. This is the only evil that this class of work suffers from when cast too quickly. But in foundries where they cast nothing else but this kind of work every casting is run at the proper speed.

In ordinary green-sand castings it is essential that the moulds should not be filled too quickly, for two reasons; first, the mould does not get sufficient time to expel the gas into the vent made by the vent-wire, especially where the mould contains a dried core, both mould and core in that case being liable to scab; second, unless the box be carefully weighted or clamped the metal will be apt to fly out at the edges, and in this way fill up the vents. Sometimes the metal gets into the vent of the dried core, and when that takes place the casting is a scrap, as the metal will then not lie at peace in the mould.

Metal which has been rushed too quickly into a large green sand mould covered with a box fifty hundredweight in weight, and say thirty hundredweight of sand, and seven tons weight on the box, will lift the whole with great ease. We do not say that it is the metal alone which does this; the efforts of the air to find an exit have more to do with it than the metal, although the primary cause is doubtless the too sudden admission of the metal into the mould. When this takes place with a large green sand casting the results are often very serious. A dry-sand mould, and also a loam mould, are always bound with clamps during the process of casting; and the flow gates are kept open in both, thus enabling the air that is in the mould to find a ready exit, and in this way lessening the chances of the mould straining. The flow-gates on the green-sand mould are kept closed until the metal

touches the top part of the mould. Were they kept open, as in the case of the loam or dry-sand mould, the air rushing out would be liable to disturb the part of the mould nearest the flow-gate, and thus create a scab. The flow-gate is therefore kept closed with a piece of clay, and a light weight of a few pounds resting on the clay until the mould is filled, the atmospheric air finding its way out through the natural interstices of the sand and between the joints of the box.

When a loam or dry-sand mould is too quickly filled a violent bubbling takes place in the flow-gates, caused not so much from any gas that the mould may generate as by the quick expulsion of the atmospheric air. This can easily be seen in casting from any dried mould that has no cores in it. When cores are in the mould the bubbling is apt to take the form of blowing, which may be described as violent bubbling. When the metal is in a hot and lively state no harm will ensue, or at all events only in rare cases, as the bubbling soon ceases, and the metal immediately falls back into its proper position. But when the metal is dull, and has little or no life in it, the flow-gate, at the first admission of metal, may set, and thus cause a hole or blown part in the casting beneath the gate. Had the mould not been run so quickly no harm would have occurred to the casting although the iron had been a little dull.

It is of great importance to notice that castings, in order to be turned, bored, or polished and planed, should not be filled too quickly, especially large castings, owing to the difficulty of keeping all the gates well supplied with molten metal. The gates are all connected by what is termed a "head," which is simply formed of sand, and to convey its purpose more plainly we might call it a large gutter, nine or ten inches deep by seven or eight inches broad. This head or gutter is again connected with a basin of wide capacity, say three feet square, sometimes made in sand or in loam, but the

latter is preferable. The basin receives the metal from the ladle to fill the head, the latter in turn filling the gates. This head, then, when the moulder begins to cast, *must be kept full*, to enable all the dirt and slag to float on the top, so that nothing but clean metal shall enter the mould. The moulder who is filling a large casting should have a firm hand and a quick eye when he handles the ladle, in order to detect every movement indicating how the mould is receiving the metal. But when the gates are too large, and the head cannot be kept full, what takes place ? Refuse and dirt from the head pass into the mould ; and, supposing the casting to be a cylinder, the chances are that it turns out to be bad in the bore. This is often the case. The mould may be all that can be desired, but, as we have endeavoured to shew, it may be spoiled in its last stage by the undue size of the gates.

The question may here be asked—Is there no rule—no defined rule—for running castings ? We say at once there is not. The size and number of runners or gates must depend upon circumstances, viz.—the state of the metal, whether run from the top or bottom, the formation of the casting, the particular object for which the casting may be intended, and many other things that moulders have to contend with. The right way of working, and the right speed at which to cast a mould, are matters of vital importance to the moulder, and can only be thoroughly attained through experience.

THE USE OF FLOW-GATES.

As the moulder has gates and runners to admit the metal into the mould, so he has gates to let it out when the mould is full. These are technically termed "flow-gates," as the metal flows into them.

Moulders engaged in light work do not use flow-gates, as

they would serve no purpose for such work. Ordinary green-sand workers use them according as the job in hand may require to keep the casting from straining. For instance, in the case of a plate four feet by five, of any thickness, flow-gates would be used, as the relief which the metal experiences in passing up the outlet considerably lessens the lift upon the box, besides relieving the mould from air. In sand work these flow gates may be put on the casting, or they may be made exactly the same as the running gates, according as the moulder may see necessary.

Flow-gates are in use for three purposes, viz., to relieve the mould from atmospheric air, to feed heavy parts of a casting, and to shew the moulder at once when the mould is filled. All kinds of metal, when in a liquid state and in a heavy mass, are sure to subside, or, as the moulders term it, "draw" after the mould is filled. In order to obviate this as much as possible the flow gates are put upon the thick parts of castings, and according to the thickness of the part so should the size of the flow'er be, that such parts may be fed with metal during the time the casting is gradually becoming set. Rod-irons, from a quarter up to three quarters of an inch in thickness, as the case may be, are used for flow-gates. When the mould is filled the moulder takes one of these rods, thrusts it into the gate, and satisfies himself that it is actually in the casting. He then works the rod up and down, in order to prevent the metal in the gate from setting. The casting gradually draws away the metal from the gate, the supply being continually kept up with hand-ladles until at last the casting becomes set in the place where he is feeding; he then gradually works up the rod as he feels the hardening process going on, until it is at last out of the cast. The feeding is then complete.

We may observe here that we are, as a rule, opposed to the plan of feeding castings, unless in cases where it is abso-

lutely necessary, such as the following :—Anvil blocks, sugar-mill rollers, extra heavy flanges on large castings, propellers, and in cases when a casting may be blowing, &c. Some moulders are too fond of using the feeding rod in every casting ; but we have known more harm occur from the injudicious application of the feeding process than we have ever known good to result from it. Twenty years ago every cylinder that was cast had a rod passed in at every gate, the number sometimes reaching sixteen or twenty in a large casting. Strangers who came to see the cast on a dark night, and in a darker shop, would not have missed the feeding process for a great deal ; they thought it the best of the whole thing. To see upwards of sixteen men, with blackened faces, surrounded by the lurid lights coming from the vents at the end of the pipes, the red-hot metal lying at their feet in the head, and each man working his rod up and down, was a sight that remained long in the memory of the visitor. Feeding cylinders, as well as many other kinds of casting in which the plan was adopted, are now things of the past.

When the moulder is obliged to feed his casting, it ought to be rightly done, that is, he should have the flow-gate of sufficient size, so that he shall have no trouble in keeping it open; and the rod should never penetrate further into the mould than two or three inches.

We remember the case of a water-press cylinder being cast bottom up, which was five tons in weight, seven inches thick on the sides, and twelve inches on the top of the core. It was fed for three quarters of an hour, and when put to use it would not hold water. When filled at night it was found to be empty in the morning. The reason of this was that the feeding rod had been kept touching (or very near) the core all the time of feeding, and that when the end of the rod was withdrawn the metal had not sufficient life left in it to thoroughly close the space left by the rod. On the flow-gate

being taken off the casting, a wound could be seen in the centre, as if a knife had made it, through which the water found its way out. It would have been a better casting had a rod not been used. If the mouth of the flow-gate had been merely kept open, and a little hot iron occasionally poured into the gate, there would have been no fear of the casting not turning out a sound one. Those castings are now cast bottom down. It was this bad use of the feeding rod which stopped cylinders from being fed; because in many instances when they were bored, the track of every feeding rod could be traced, the parts where they had been being quite spongy.

When any portion of a casting has to be turned or planed, and that part to do a deal of work, it is not advisable to have a flow-gate there, as the part where the flow-gate has been is sure to be much softer (and, if it has been fed, spongy) than the surrounding parts. For example, not a few oscillating cylinders have been condemned owing to a spongy part appearing on the trunnion. The moulder, in his endeavours to make that heavy part of the casting sound and clean, puts a large flow-gate on the top of the trunnion, and in this way spoils his casting. Cylinders of this description have been cast with large flow-gates on the trunnions, been fed, and have turned out badly. They have been cast with flow-gates, but no feeding, and have also been bad. It may here be asked—Then why put flow-gates there at all? Would it not be better to dispense with flow-gates altogether, seeing that the trunnion is placed so far down the casting, is subject to a great pressure of metal, and therefore conducive to the soundness of that part, although it has an extra thickness? We should say—Yes, that is quite true, you have exactly explained the reasons why a flow-gate should not be there; but the engineers who have ordered the cylinders desire to have a flow-gate. It is their idea. And such has been the

case. An engineer, who occupies a high position in his profession, wanted a propeller made and cast from re-melted iron of his own mixing. So careful was he of his mixture that he would not trust the moulder, but sent his own man with strict injunctions to tell the moulder to put a great many flow-gates near the top edge of the blade. The moulder demurred to this, not so much on account of the extra trouble, but because of the absolute uselessness of the injunction. In due time the engineer came to the foundry himself, and demanded to know why the moulder refused to put the flow-gates on the blades of his propeller, so as to take away the dirty metal from the leading edge. The moulder informed him that owing to the construction of the propeller, and the manner in which it was cast, the top of the blades would be as clean as the bottom, because of its wedge-like form, and that putting flow-gates on the place would tend to bring about the very thing which he (the engineer) wished to avoid, viz, the eating away of that portion of the blade by the water, owing to the skin of the casting being broken. The engineer then desired to know how it was that one foundry could supply a propeller that would last much longer before shewing signs of decay on the blades than another foundry could, if it were not that the one had better metal and was cleaner on the blades than the other. The moulder endeavoured to explain that there might have been some difference in the pitch of the propellers, but the engineer would not be convinced, he said he knew better, and intimated that the moulder did not know very much. It is to be hoped that the moulder took it all in good part, as he may have learned before this time that an engineer's opinion of moulders is, as a rule, not of the highest order.

Flow-gates on the blade of a propeller can do no good, except that they may ease the strain of the metal when the mould is nearly filled, as in the case of the plate described in

the green-sand mould; but breaking the skin of any casting, as a flow-gate or gates would do, that is subject to the action of water is to be deprecated. Flow-gates on a propeller should, like any other casting, be put on the right place, which is as near as possible on the top of the boss and above the blade where the thickest part of the metal is.

Some moulders imagine that the plan of having a great many flow-gates on a surface that is to be planed or turned (not a working part) makes a nice clean casting. We believe that it does tend that way, but not quite so much as is perhaps generally supposed, The casting may be dirty between all the gates, the clean spots shewing where the flow-gates were. It is a better plan to allow a little more than the usual margin for planing and have a clean cast, a clean mould, and metal in good condition in the ladle. We should say that these precautions will produce a cleaner casting than having flow-gates.

Hard metal is very apt to draw or subside. Some engineers wish to have castings of a certain kind cast with hard iron. Now, if the thickness of the metal be not uniform, and a heavy part or parts be in the casting, these places will be liable to become drawn. With hard iron it may be in a very unlikely place on the casting where the moulder could not reach, even if feeding through a flow-gate could have done any good. This probably would not have taken place with ordinary metal. With hard metal the case is very different.

We dislike the plan of feeding except in cases where it really cannot be avoided, because we are convinced that it is seldom carried out properly. How often has a good mould been spoiled through a moulder's heedlessness in pushing his rod roughly into a mould and thus breaking a core, the metal getting into a vent and blowing the top off the casting! How often has the rod, when of common iron, broken off at the place where it entered the molten metal, and quietly slid

into the barrel of a cylinder, the moulder perhaps saying nothing about it until the bore disclosed its presence! And how often does a moulder keep his rod in the casting far too long, not fully realizing the necessity of gradually and very carefully working his rod out as the metal sets!

Then, to avoid feeding, except in the case of such blocks as we have already mentioned, let the flow-gates be large where the metal is heavy; and when the mould is cast with good iron these large flow-gates should remain long enough in a liquid state to supply the casting, they will then both set simultaneously.

On the other hand, it must be admitted that there are some castings which would be prejudiced by the imposition of extra large flow-gates, as the process of chipping the latter off might endanger the integrity of the result. Sometimes a casting may require to be run by two or three large gates, such as large spur wheels, heavy pinions, &c. Such castings being run at the centre, and that part being heavy, recourse must be had to the device of feeding with the rod iron, as the gates of themselves, although large for runners, could not feed the casting. Again, in the case of a large cylinder, with a heavy face, having a flange three inches thick, a flow-gate could scarcely be put on sufficiently large to feed the surface, recourse must then be had to the rod; but the moulder should bear in mind that he is *only to keep the flow-gate open*, and not to ram his rod twelve inches into the casting. When the moulder finds himself obliged to feed his casting, his rod should be made red hot previous to its being thrust into the flow-gate, since a cold rod precipitates the settling of the iron in the flow-gate. When flow-gates pass through a loam plate care should be taken to have the hole in the plate made larger than the intended flow-gate, so that some portion of loam may intervene between the plate and the gates. Where there is no loam, and the metal has to flow on to the bare

plate, the gate may set too soon to feed the casting; besides, a strong gate may seriously interfere with the proper contracting of the casting, not to speak of the trouble which is apt to be experienced in taking the plate off when the casting is cool. The same precaution should be observed with regard to running gates; and in green sand or dry sand an inch of sand should be between the bars of the moulding box and the flow-gates.

Flow-gates are always put upon the highest part of a casting. We scarcely approve of them in any other position unless they are two and a half inches in diameter, so as to rise freely to the level of the head or highest gate. Flow-gates are good when put upon the proper part of the casting. As to their number the moulder may put on as many as he thinks fit; they will do no harm, and not much good; but simply have the effect of giving him a little more labour in putting them there, and of causing more labour to the cleaner in removing them from the casting.

LIGHT GREEN-SAND CASTING.

The phrase "light castings in green-sand" might be more appropriate than the above heading. We have chosen the latter by preference simply because moulders are accustomed to use it.

The sand to be used for light casting ought to be of a fine and superior quality, besides having certain chemical properties which may all be found in one kind of sand, or in a mixture of two or three kinds. It should be close in the grain and of a soft nature; close in the grain, because little or no vent is required to come from light castings, the heat of the metal not being great enough to generate, or rather to expand, the gases contained in the sand. It should also be fine-grained, as no tools can be applied to the moulds in order to

make them smooth. Were the sand open or coarse the castings would be rough. The moulds of light castings are cast just as the pattern leaves them. The chemical properties contained in sand are supposed to be alumina, silica, and magnesia. Some sand may also contain a little lime.

Erith sand and Belfast sand possess all the qualities which are requisite to make light and fine castings, each kind being sufficient in itself without any other mixture. One advantage—if it is an advantage—the Erith seems to possess over the Belfast sand, namely, the mould can absorb a greater quantity of water when swabbed without doing much harm to the casting.

As the sand for light work is fine-grained, so has the coal-dust to be of the finest, well ground, and passed through a hair sieve, the quantity of coal-dust being determined by the nature of the castings required. Too much coal-dust makes some castings blunt where they should be sharp, and also more difficult to run. We have seen castings not run up and made bad solely owing to there being too much coal-dust in the sand. This coal-dust sand is termed "facing sand," as it is sieved on the pattern, and forms the face of the mould. It is kept apart from the ordinary sand employed to fill the boxes.

Parting sand—so called because by it the moulding-box when rammed up is separated from the pattern—when used for light work must be very fine and of a quality that will not take up moisture. It should be free from clay or lime, and the lighter it is in colour the better. Some foundries prefer burnt Belfast sand, others fresh water sharp sand, others the sand that has formed the bottoms of large ladles after they have been used for a considerable time and have been cleaned out, while some others choose burnt sand taken from heavy sand castings. We prefer the first-mentioned kind, or that which is to be had from the bottom of the ladle.

Light green-sand moulding may be classed under three heads—(1) hollow work, (2) flat work, (3) jobbing work. Castings that fall under the name of hollow work are pots, kettles, pans, water-runs, boilers, ovens, and such like castings of a hollow form. Flat work includes grate metal, castings for sanitary purposes, and balconies or balustrades to form railings. These two classes are a speciality; they stand distinctly apart from each other in their modes of moulding, and the flat moulder would make but an indifferent hand at hollow work, and *vice versâ*. Jobbing work comprises jobs of any kind, no matter what they may be, from a smoothing iron up to a large lathe-bed. The jobbing sand-moulder is ready to undertake anything that may come in his way, even to making a pot, a grate, or a balcony.

LIGHT GREEN-SAND WORK.

By "casting" is meant the process of converting fusible metal into any given form by pouring it when in a liquid state into a mould. There is no article capable of being produced in wrought iron which the sand-moulder cannot cast in metal; nay more, an ingenious sand-moulder can produce in cast iron what no worker in wrought iron would dare to attempt. It does not come within the scope of the present treatise to enumerate everything for which science and commerce are indebted to the iron-founder; but among the most striking may be mentioned those which have superseded the use of wood and stone—as frames for machinery, waggon-races, spandrils for roofs, columns, waggons, bridges, barges, churches, bearers, doors, and window frames; in fact, time and paper (if we may use the phrase) would fail us to enumerate the uses to which cast-iron is now applied.

Like every thing else the art of moulding has made great advances in all its branches, but more especially in light

green-sand moulding. The old adage that "necessity is the mother of invention" has held good in this branch of industry to a marked degree. The great demand for light cast-iron work (ornamental and useful) that has taken place within the last twenty years has brought out the ingenuity of men who were not, in some instances, moulders at all, to devise some kind of mechanism to assist the moulder in this object, and the result of their inventions has been most gratifying.

Suppose we speak first of light ornamental work, such as balconies as they were moulded twenty years ago. It was then considered to be a good two hours' work to ram the drag part of a box (bottom part) that contained an ornamental balcony 4 feet by 4 feet 6 inches, and make its parting all ready for the top part, and this when the moulder had a turning-over board to assist him. At the present time a moulder can make two such balconies ready to receive the metal in three hours. If we take balusters, it was considered twenty years since a good morning's work of three hours to mould one box of five balusters, and make the parting of the second, with the assistance of a turning-over board. A box of the same kind of balusters can now be moulded every hour.

This improved plan of moulding is done by what is termed "plate moulding." A plate sufficiently large for the edge of the box to rest upon is cast with the exact half of the required pattern, the boxes having planed edges to fit closely on the plate, where provision is made to ensure that every box shall fit to a hair's-breadth in the same position, and each half of a box is also made to suit its other part to a hair's-breadth when they are joined together.

The principal object in plate work is to save time in making the parting, and to facilitate by a simple mechanism the turning over of each part of a box when rammed. Herein

lies the whole secret of plate-moulding. When wood turning-over boards were in use they were supposed to be quite capable of being moulded from. A rude and roughly-made shape of the desired pattern was cut into the wood to receive the exact half of the pattern, the fine ornamental parts of the pattern being unheeded after the box was turned over and the board lifted off; then began the work of the moulder to make the parting at the proper place in the intricacies and more delicate parts of the pattern. This of a necessity took a long time, as the parting in this kind of work must be rightly and properly made, otherwise poor castings are inevitable. We may say here in passing that making the parting in moulding, in all its branches, is a most important item for the moulder; first, the best place to make the parting; second, to make the parting correct after the place has been decided on. In some patterns the parting can only be made in one place, and that the centre. This applies to all round bodies, such as pipes, columns, round balusters, light ornamental work, &c. In other classes of heavier work the moulder's experience and taste lead him to the proper place in the pattern where the parting should be made. Hence the great necessity of something to aid the moulder in making his parting in light green-sand work, resulting in what is well known as plate moulding.

This method is greatly in use for other classes of work besides the ornamental, namely, looms for mills, sewing machines, and various other articles.

Some foundries use plaster of Paris for their patterns instead of iron, but on the same principle as the plate-moulding, with this difference, that the plaster pattern is on a box of exactly the same kind as that from which they are to be moulded, the same machine being used to turn them over when rammed up. Not only does plate-moulding make the parting, it draws the pattern as well, and far more steadily

and better than the moulder can. When a frame for a loom or a balcony pattern had to be drawn, before plate-moulding came into use, it required three and sometimes four moulders to do it; in this way taking the men from other work. These four men were not necessary on account of the weight of the pattern, but because each had to take a corner so as to ensure a steady draw.

When the job in hand requires a large box, say five or six feet square and six inches deep, hydraulic power is made use of. The ram being down at its lowest, the half-box or plate containing the pattern is laid upon a sole plate on the top of the ram. The half-box to be rammed up is then lowered by the crane on to its place. After the ramming is complete a simple piece of mechanism fixes the box or plate together, and the ram is then raised to the proper height, so that the box may have room to turn completely over on swivels cast on the box. On each side of the ram are pillars, where provision is made for the swivels of the box to catch, and the ram being lowered, the whole is turned over. The ram is again raised to receive the rammed-up box, another provision being made from the pillar to retain the plate or box with the pattern whilst the rammed box is slowly lowered down to the ram's seat. The other part of the box is done in like manner; they are then both put together and clamped, and the mould is ready for casting.

The small work in plate-moulding is of course done by hand, but it is on the same principle as the above.

PLATE MOULDING.

This class of work is a speciality, requiring special appliances to enable the moulder to turn out a large quantity of work. We do not regard it as moulding proper. An apprentice brought up wholly, in the strict sense of the word, to this class of work could scarcely be termed a moulder;

he would be quite ignorant of the fundamental principles of founding, having neither vents, cores, chaplets, binding, nor different plans of running to contend with. It is a mastery of these that constitutes a moulder.

In all kinds of light work made, or assisted to be made, by machinery, no expense is spared in getting up first-class patterns, which, as the moulders say, would mould themselves. In order to save ramming, boxes are made the exact shape of the pattern, but four or five inches larger all round, for the purpose of bearing, otherwise the edges are planed, holes for pins are bored, and pins turned. This work is expensive at first, but the quantity of castings wanted requires it to be done. The moulder, then, has little more to care for than to keep his sand in good order and ram it to the requisite degree of firmness. By good order, or condition, we mean the sand to be often riddled and sufficiently damp to make it cohesive. It is better to err on the dry side than otherwise for this class of work. The metal used for these castings should be of the softest and finest brand, known as No. 1. Two reasons require this—first, the greater fusibility of the metal and adaptation for running; and, second, the damp sand tends to make the metal hard, the castings being so light that they become in a manner chilled through losing a portion of the carbon in the metal.

The apprentice who is taken from the core-bench in a foundry where no speciality is carried on in castings of the class we have just described, but where he may have had to make moulds of every conceivable shape and form, will make the best moulder, more especially if he has been a good core-maker. The little jobs which he gets to mould he may think insignificant, but such is not the case in reality. If he cannot learn to mould a small one well, he will never be able to do a large one well. In light green-sand jobbing work nearly the same routine has to be gone through as in heavy green

sand, the difference being that the appliances are smaller and not quite so elaborate.

We will now consider and explain, as precisely as may be certain things to be observed in moulding light jobbing green-sand castings. First, the facing sand and sand for filling the box must be in good order; that is, free from scraps and not too damp; but it is impossible to state in words the exact degree of dampness required; experience and practice alone can define that. We might say that the sand is damp enough when it is fit to crush into a ball by the hand; but the fact is that sand too dry for moulding can be made into a ball with a little trouble, and the same thing may be done with sand too damp, with only this difference, that the operation is quite easy; a medium consistency, then, is the right thing. Bad results occur to small castings when the sand is the least shade too damp; the body of metal being so light in the mould, and the sand not so porous as it ought to be owing to the dampness, the metal cannot rest and is thrown out at the gate, if not all, a portion sufficiently large to cause a bad casting. Another evil takes place even when the metal does lie in the mould—the casting is liable to be slightly chilled, producing on the top when the skin is broken small "porie" holes, as if worms had made their abode their, and the casting having all the appearance of being cast with No. 4 iron, instead of with No. 1 or 2. The dampness takes a certain portion of carbon from the metal, thus changing its character, as in the case previously mentioned. When the moulder finds that his day's work of casting has been done in sand too damp, he should put no water on his sand for the next day's moulding. In this way the sand will be restored to a proper consistency.

In all kinds of light work the castings are taken from the sand soon after being cast, which generally closes the day's work. Two reasons call for this being done—first, if the

castings were left in the mould till next morning they would shew signs of becoming oxidised, or rusty ; second, the sand is better to lie over night after being watered ; in the morning it only requires to be turned over and raised in a long heap, when it is again ready for use. The moulder should keep his shovel perfectly clean and bright.

In all kinds of small jobbing work, as in machinery or agricultural implements, the patterns, if they are rightly made, will clearly shew to the moulder what part of the casting is intended to be cast upwards ; the pattern being slightly tapered, the narrowest part will be cast in the bottom part of the box. When the pattern has a flat service, and that the widest or largest part, a board is used, termed a turning-over board, because it retains the pattern during the time that the box is being turned over after being rammed up ; this board is made for the purpose, and of a proper size to suit the boxes that are generally used for small job castings. These boxes are generally twelve or fifteen inches square and four or five inches deep, having pins fixed on three snugs, two on one side and one on the side opposite, with a handle on each of the other sides ; this is termed the drag or bottom part. The top part is a fac-simile of it, only it has holes in the snugs to receive the pins. From one to twenty small patterns may be put into one of these boxes and all cast together.

The drag part being rammed up and turned over on a soft level bed, the parting is next made as follows :—The sand close to the edge or edges of the pattern is made firm with the fingers, and soft hollow parts are filled up ; a sprinkling of loose sand is smartly thrown over all with the left hand, the right hand sleeking all down smooth with the trowel. The loose sand remaining can either be brushed or blown off, and the pattern is then ready for the parting sand. Care must be taken that little or no parting sand is allowed to remain on the pattern, however fine it may be, as the castings in that

case would be liable to shew some roughness on the top. The top part is next put on, the moulder noting that the box is bearing properly, that is, not rocking. In jobbing foundries the boxes, as a rule, do not fit well; the edges on which they rest are rough and unequal, the pins slack, and the holes get worn wide; however well they may have been fitted up at first, after being in use for some time they become misplaced, and ultimately they get so mixed that out of the whole original number there may not be two that can be said to fit properly. In order to obviate the results of badly-fitting boxes every moulder should, when he is putting on a top part, incline the box hard one way; this inclining is termed "sun about," or the way the sun travels; and the same rule is observed when the box is closed previous to casting.

The gate-pin is now set into the box; it is a piece of wood eight inches in length and one-and-a-quarter inches in diameter, slighly tapered, and having a sharp point. When there is more than one pattern in the box the pin is usually set in the middle; but when there is only one it is set two or three inches from the side, or it may be set on the top of the pattern, according as the latter may require. The top part is now rammed up in like manner to the bottom, and the sand is scooped out to a certain depth round the gate-pin, so as to form a cup shape, in order that the metal may easily be admitted from the ladle into the gate.

The proper and careful formation of this cup shape round the pin is of considerable importance, more so than many moulders imagine, because when it is well shaped and as deep as possible the metal is passed into the mould cleaner than when it is otherwise, and a clean cast for small castings is very important. The top part is now lifted off and laid upon its back, and the sand close to the edge of the pattern made damp with water, either with a brush or swab, so that the edges of the mould may become firm; but too much water in

swabbing small moulds is bad, as the edges of the castings become chilled and difficult to file or chip, therefore the less of swab water the small moulds get the better. Should the pattern be iron or wood it must be shaken in the sand before being drawn. When it is wood a sharp spike or strong nail should be driven carefully into the pattern and gently rapped from right to left until the pattern in a manner feels free ; when iron a small hole is drilled for the purpose of rapping and drawing, it may then be steadily and smartly drawn out, so that, when the pattern has been properly made, it leaves the mould free from a disturbed part. The moulder has then only to cut a small runner from the mould to where the gate-pin has been inserted, and the mould is then ready for casting.

Many foundries use blacking on all kinds of sand work, both light and heavy, the dry blacking being put into a small cotton bag for light work, and into a coarse flannel bag for heavy work, the bags being shaken close to the mould until the proper quantity has been retained on the sand. Where rotten rock and Belfast sand are used for moulding the blacking bag is always adopted, the grain of this sand being so open that did it not receive a certain portion of blacking to fill the pores the castings would be very rough ; but where Erith sand is used there is no need for the blacking bag, the texture of the sand being much finer than the others.

The blacking of sand moulds is done for two purposes—first, to fill up the pores in the sand ; second, to make the casting skin, that is, to cause the sand to quit the casting freely, assisting in this action the coal dust that has been mixed with the facing sand. When blacking has to be used it should be of the best quality, viz., heavy and thoroughly calcined, so that it may be impervious to the heat of the metal, otherwise it will do more harm than good by getting burnt in the mould, and the residue running before the metal into corners of the mould, giving the casting an appearance

of having been cast with dull iron, as well as being rough. The patent blacking brought to the notice of moulders about eight years since by a Glasgow firm, completely fulfils all the requirements of good blacking.

But even with this patent blacking light castings, or rather moulds for light castings, should receive as little of it as possibly can be done without, especially small ones which have to be turned or planed. They are much cleaner cast in Erith sand, with a proper quantity of fine coal dust in the facing sand, and no blacking. For ornamental work moulded in any kind of sand it is enough when the blacking can just be seen on the mould. In heavy green-sand work blacking can be used with more freedom, as in such cases it can be pressed and sleeked with the trowel and other tools into the pores of the sand, thus making a smooth mould, and rendering it impossible for good blacking to run before the metal at the time of casting.

When small castings require holes running through them, either round or square, the moulder should see that the cores he has to put into his mould are of the proper form, not to have a core more oval than round, or what should be a square one not square at all. Few things look worse in a small casting than a misshapen hole, or when they are not perfectly straight in the casting. The moulder should make certain that the vent is clear and the core dry. He may take his vent either through the top part or down through the drag; some moulders prefer the one to the other, but the vent must come off whether it be up or down. The cores should not be put in the moulds till near the time of casting, as they soon absorb the moisture from the green-sand; but when it happens that the moulds are not cast on the same day as they are cored they should be taken out and cored next day. When they are left in the mould till next day, as is sometimes done, every casting is sure to be more or less blown.

HEAVY CASTINGS IN GREEN-SAND AND DRY-SAND.

Green-sand and dry-sand moulding are both executed nearly in the same fashion. In working dry-sand more liberty can be taken with the mould during the process of moulding, and, after the mould has been dried, in putting it together to make ready for casting.

Heavy work in green-sand means castings of from five hundredweight up to ten tons in weight, and sometimes even more. As the method of moulding light green-sand castings has improved during the last twenty years, so also has heavy work done in green-sand and dry-sand. Elaborate and intricate castings that used to be cast in dry-sand are now executed in green-sand, and work that was wont to be done in loam is now successfully carried out in dry sand. What, then, shall we say of the moulding machines for heavy work that are now in common use, such as for ramming up pipes, railway chairs, telegraph posts, and, notably, wheel and pulley moulding machines ? Again, the moulder can chill and make harder than steel any part or parts of his casting that may require it. And, lastly, he can make castings from metal which are almost equal to malleable iron in tenacity and softness.

It would be entirely out of our proper province—viz. iron founding, or the art of moulding—to explain either with plates or diagrams the different moulding machines which some foundries, where special castings are made, have now in daily use ; but we cannot refrain from saying a few words about one of them—" Scott's Manchester Wheel and Pulley Machine." For simplicity of design, the quality of not being easily put out of order, and the merit of being suited to its work, this machine cannot be surpassed. No

foundry where pulleys or wheels of any size are occasionally made should be without it.

We will, then, confine ourselves to green-sand and dry-sand moulding wholly done by hand, and of such a nature that machines could scarcely be applied to it.

The green or dry-sand moulder may have occasion, as circumstances require, to work with a one, two, or three-part box; and the dry-sand moulder has sometimes to do without a box of any description, merely casting a rough plate, which when large is three and a quarter inches thick, the proper shape of the pattern allowing it to be nine or ten inches larger all round for bearing. This plate is cast full of square holes, nine inches by five, to enable the moulder to ram the sand on the top of the pattern, the plate having "prods" or "dabbers" six or eight inches long (as the pattern may require) to retain and carry up the rammed sand. The pattern in this case would have to be moulded in the foundry floor and dried there, the plate merely covering the top surface.

When the moulder cannot get a two-part box to suit his pattern he will proceed to mould the latter in the floor. This is termed "bedding it down," and it then may be covered with a one-part box.

In primitive moulding this would not have been thought of. Two parts of a box were then used, and the boxes were made of wood, and wooden boxes are still in use in some of our agricultural districts; also in many foundries in America and the East and West Indies. But in great industrial centres where foundries flourish, and where the blaze of the cupola is seldom extinct—where the castings are heavy and cosmopolitan, being of every conceivable shape and form, the wooden box would be of no use whatever. Although moulding in a box with two parts is decidedly the best for the pattern, better for the moulder, and best of all for the casting, still no foundry that pretends to do anything like a

casting business could really entertain the idea of moulding all its castings in two or in three-part boxes, and this for two reasons—(1) the great number of boxes that would be required; (2) the great weight of, and the difficulty and danger in handling, heavy two-part boxes. Hence the plan of bedding down patterns in the floor is resorted to.

A moulding box, whether intended to be used in green sand or dry sand, but more especially the former, ought to be strong and rigid, giving no signs of yielding when filled with sand, or during the process of turning it over. When the casting is long, say twenty feet, it is usual to cover it with two boxes, the moulder choosing the best place where to make the joining, so as to shew the least possible mark of the latter upon the casting. The two boxes are easy to handle, take up less room on the foundry floor, and no risk occurs of the box yielding, as it certainly would be liable to do unless it had been made enormously heavy.

When two boxes are used to cover a long mould great care has to be observed in forming the joint between the two. When they are first put on in order to be rammed up, it is requisite that the two ends next the joint should be an inch separate, which space allows three-eighths of an inch of sand to be put on the end of each box, this being done after they are parted from the pattern, so as to allow a quarter of an inch of space between the two after they are closed. This space is called "the fin," and cannot be dispensed with in this case, as it would not be safe to make up the sand so as to fill up the entire space between the boxes.

Some moulders are accustomed to use clay water for the purpose of causing the sand to adhere to the ends of the boxes. This is most reprehensible, unless the water be put on with extreme care, as it causes the sand to be too damp; the metal rising up in the space, a violent commotion at once takes place, penetrating down into the mould, and in many

cases ruins the casting. The safest plan with a joint of this description is to oil, instead of clay-wash, the ends of the boxes; the sand will adhere equally well, and should it be very moist with the oil no irruption will be caused with the metal. After the boxes are closed a little waste hemp or flax is gently stuffed into the joint, over this is packed some fine sand, and light weights are laid upon the top of all, when the securing of the whole may be considered complete.

The materials which the green-sand moulder uses are—sand, pieces of iron (cast or malleable) to strengthen parts of the mould where they may be required, and a box or cast-iron frame with traverses, commonly called "bars," running across at proper intervals or spaces, according to the depth of the box. These bars stiffen the outside frame and hold the sand firm that has been rammed between them, so that the pressure of the metal can take no effect in forcing the sand out.

In foundries where all kinds of work are executed the boxes will be varied in size and in weight, from thirty pounds up to three tons. It is of great importance to the sand-moulder that he should have a good and well-fitting box to mould his job in; the box, however, is too often the reverse of this. The operator in a jobbing foundry has often many schemes to devise, and much time is spent in making a mould with a broken or badly-suiting box. Some of the most suitable boxes for jobbing foundries of which we know are those made with deep sides, say nine inches, and shallow bars of four inches. They may be from three to five feet broad, and from ten to thirteen feet in length; and no foundry should be without a few of them. They suit well in many instances for saving deep lifts and economising time in making elaborate partings; besides, they can be turned upside down and used for a mould, having a plain surface and a plain parting.

A sand-moulder may get a pattern to make a casting from

which really puzzles him as to which way will be the best to mould it. The piece of work to be moulded may require portions of the pattern to be made in such a manner that they will separate, one piece from another, and according to the pattern-maker's point of view this may be the way it should be moulded; but when it comes into the moulder's hands he at once sees that the pattern has not been made with the best idea of how it should be moulded. This occurs in many instances, and gives a great deal of extra trouble to the moulder. After considering how to run it in, and the vents from the cores (when there are any,) he is obliged to decide on the best way to mould it by reference to the only box that will suit, and that may be very imperfectly fitted for the purpose. It is the prevailing custom in many foundries to break a bar or even two out of the box to make it suit the pattern, on account of the pattern coming in the way of a bar or a bar coming in the way of a part of the pattern. This practice should be avoided as much as possible, as the box when deprived of its traverses in this matter is liable to become useless for moulding purposes.

Moulding boxes made with the intention of applying them to many jobs, and not one in particular, ought to have the bars cast separate, and bolted to the outside frame; the bars to be cast double, so that one bolt in each end will hold two bars. In this way bars can be taken out to suit the pattern, and they can be put in again without the box being injured. Boxes of this description would certainly cost more to begin with, but they would be cheaper in the end.

The foundry floor is now used extensively for moulding purposes, much more so than it was twenty years back, the reason being that moulding is now better understood than it was then. A pattern can now be bedded in the foundry floor in the same time that it would have taken a moulder to look for a two-part box in which to mould his job. Seeing that

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such a custom is now general in foundries, we cannot do better than proceed to explain more fully the art of moulding in green-sand with a one-part box, generally known as "bedding the pattern down."

A great deal depends upon the formation of the pattern as to which way the moulder will proceed after the hole is made to receive it. When the part of the pattern that is to be cast downwards presents a plain surface a levelled bed of riddled sand is first made in the bottom of the excavation; three inches of common riddled sand and one inch of facing or coal-dust sand should be between the surface of the bed and the top of the ashes intended to carry off the vent. This bed of sand should be made very carefully, is seldom rammed with a rammer, and when it is rammed the operation is performed very slightly; tramping with the feet is generally sufficient for the heaviest green-sand castings. This bed of sand is formed with two pieces of wooden laths, each having a perfectly straight edge, known in some foundries as straight edges, and another one, generally called a parallel straight edge, rests upon the other two, parallel with them, as they are levelled by it. The sand being now straked off, and the bed having being vented, facing sand is sieved all over it and the whole sleeked carefully down with the trowel; it is then ready to receive the pattern. Should there be any protuberant parts on the face of the pattern, such as prints for cores, facing strips, and the like, they will make an indentation and keep the pattern from resting upon the bed. It must then be lifted off, after it has been carefully staked, so that it may go into the same place again. The projecting parts are taken from the pattern, and they are then sunk flush into the bed. When there are to be cores in some part of the mould, small wooden plugs three inches square, or little cast-iron sockets, are sunk into the bed two inches below the surface, and at arranged distances from each other, in order

that the chaplets to carry the cores may rest upon them. When the plugs are wood, the chaplet-stalk has a sharp point, but when iron sockets are used, the stalk is kept blunt. This arrangement only applies to green-sand.

It is sometimes advisable to finish this part of the mould in its early stage, as the moulder can get to work at it with greater freedom, and therefore, it is more quickly done than when the whole mould is made. The pattern is again laid on the bed, this time resting equally all over, the stakes are withdrawn, and the ramming up of the outside is proceeded with. The formation of the outside may require some part or parts of the ramming up to be made so that they can be separated to enable parts of the pattern to be taken from the mould and allow the moulder to get these parts finished. When such is the case these are termed "drawbacks." The part of the mould that is to remain in the floor is first rammed up, and pieces of board set up at those places where the fixed ramming terminates and the drawback begins, so that the moulder may have something to withstand the ramming. A course or depth of six inches of sand is rammed at a time until the top of the pattern is reached, two inches of facing sand being kept close to the pattern. On every second course of sand pieces of iron, cast for the purpose, are laid three quarters of an inch square and twelve or fourteen inches in length ; they are laid horizontally, three inches between each, and clay-watered at the ends that go next to the pattern, being kept back half an inch from it. These irons strengthen the sand, and materially assist the gases to leave the face of the sand forming the mould.

When the mould has been half-way rammed up it is advisable to strike the pattern in a lateral direction all round with a heavy hammer, which slackens it to a certain extent and causes it to leave the mould more easily when it has to be drawn. The parting for the drawbacks are now made.

This is an important part of the moulder's work, as a well-made parting, and good parting sand, constitute two of the necessary elements that go towards effecting speedy closure of the mould. By a well-made parting we mean that the sand should be straight, regular, and firm ; the parting sand that is put upon the sides must be wet to enable it to adhere, and should be of a fine quality. A plate cast for the purpose is usually made to carry the sand that forms the drawback, and according to the weight of sand that it has to carry so will its strength have to be. It should not when lifted from its bed give the least signs of yielding. If there are three feet of sand the plates are generally cast two and a quarter inches thick and fourteen inches broad. They are usually bedded the thickness of themselves below the lowest part of the pattern, and have a bevelled edge, which is to be upwards, so that sand on it is not required. These drawback plates have two or three wrought iron lifters cast in them at proper intervals, for the purpose of slinging them when they are to be hoisted out of their places.

Drawbacks are rammed up in the same manner as the part of the mould that is to remain in the floor, except that double the number of strengthening irons are used, they being put in *every* course of sand, instead of every second one.

The pattern being now all rammed up to the top, the box that is to cover it is now tried on and placed in such a position as will suit vents, running-gates, and flow-gates. It is then securely staked at each corner, lifted off, and the parting made.

When the parting has a level surface it is necessary to put two inches of facing sand upon it previous to the box being put on for good, as the cross-bars or traverses coming hard on the sand make the face of the bars firm. Where the pattern is three or four inches (and sometimes more) from the bars this would not require to be done.

Assuming the box to be in its place, and the gate-pins in their places, the box only remains to be rammed up. An inch or so of facing sand is riddled from a quarter riddle all over the pattern and parting, and cast or wrought irons, made for the purpose, are plentifully distributed between every pair of bars in the box, care being taken that they do *not* stand higher than the bars. These irons are sometimes called "lifters," from the two inch toe that is cast on them, and in some foundries they are called "hangers." They are for the purpose of strengthening the sand between the bars of the box and the pattern. When they are too near the face of the mould—say that only a skin of sand intervenes—marks of them will be seen on the casting. Marks of the bars will likewise be seen when they are too close to the casting. As the sand is liable not to be rammed properly, lumps or swellings are seen at every bar. Again, marks may be produced on the casting when the bars are at too great a distance from each other, especially when the pressure of the metal is considerable; between every two bars the casting will be slightly swollen, this being seen very plainly after the casting has been painted. The distance between each pair of bars should never exceed six inches for heavy work; and the sand on the face of the bars should in no case be less than an inch. This rule applies to round bodies just the same as to flat surfaces.

The box being lifted off, and the vents all attended to, the edges of the mould close to the pattern are freely swabbed with water; the pattern is then slackened in the sand by the use of a strong bar inserted in the places appointed, and a heavy hammer is applied in striking the bar in a lateral direction.

A green-sand mould of this description, made with either Erith sand or rotten-rock and Belfast, will be finished much after the same manner, if we except that when made with the

sand first spoken of water is used much more freely all over the mould than with the latter. A mould of this kind when made with Erith sand would be slightly dried—or rather, skin-dried—with fire-lamps after being finished, and it would not be blackened with blacking ; a greater quantity of coal-dust being used in this instance with the Erith facing sand is capable of making a good skin on the casting.

The drawbacks being lifted from their places, every part of the mould will be finished in detail, soft parts made firm, and three or four inch brads used freely where parts of the mould have been started or torn up with the drawing of the pattern. Fillets or round corners must be made regular, and a small vent-wire (13-wire gauge) passed freely from all prominent parts of the mould to catch the larger vents that were made before the pattern was drawn, and the whole is carefully sleeked with the trowel or other tool that may suit. When, however, the mould is made with Belfast and rotten-rock sand it is not entirely finished until it has received a heavy coat of dry blacking shaken out of a bag.

If the pattern happens to be of such a construction that it offers no place to rest upon on a level bed, it is merely laid in the place that has been formed in the floor for it. Coarse riddled-sand is rammed as well as possible under the bottom parts, and it is then staked and lifted off, the soft parts made firm, prominent parts carefully ironed, the vent-wire passed freely to the open bed below, and the whole covered with facing-sand. The pattern is then put on its place and rapped or struck with a heavy hammer until the moulder is satisfied that the sand underneath is sufficiently firm, when the rest of the ramming may be proceeded with.

Moulding in green-sand with dried cores may be considered a mixed operation, and the moulder should be as conversant with the nature of the cores that he uses as he is with the sand from which he has made his mould. An important

piece of work may be ruined simply owing to a small core being defective. When, however, a moulder has been a good core-maker he will have no trouble in finding out any imperfections that may exist in his cores, such as improper sand and venting, imperfect drying, and a lack of careful strengthening with irons. When a moulder gets a core betraying any of these imperfections he should on no account put it into his mould, even though such carelessness should furnish him with the too common excuse after the casting has been found to be faulty—"The core that I used was not this or was not that." Such a plea is scarcely an excuse for a bad casting. A careful moulder will have an eye to the making of his cores during the time that he is getting his mould ready to receive them. Cores are especially used in forming vacancies in castings which cannot be successfully formed by the pattern.

There is one evil that attends bedding a pattern down, and it is a common one, especially when the pattern has not been firmly put together—the moulder is liable to ram or rap it down out of its proper shape. This is more particularly the case when the pattern is so formed that the under part, or that part which is to form the bottom of the mould, has to be rammed up first, and then turned over on a bed of sand. For instance, an H-shaped beam would be moulded in this manner, and many are rejected from this cause, the casting not being square.

BAD LIFTS WITH THE TOP PART.

When a pattern on the top, that is, the part which is moulded up, presents an irregular surface, dropping in many places eight or ten inches, these deep parts must be carefully rammed, and the rammed sand secured with irons for the purpose. When this has not been done, or done only imperfectly, a bad lift is the result—meaning that all the sand has

not been brought clean away with the top part, the moulder having then to rectify and mend up the broken parts. Again, a bad lift may be caused through a pattern being badly made, parts of it having no taper or draw, but being perfectly square. When such is the case, after the pattern is drawn from the mould and the top part mended up, the box should be put on its place, and in this way any imperfections can be found out, in many instances preventing the mould from being crushed after it has been finished, as is liable to happen when this is not done. A good and clean lift with the top part should be the desire and aim of every moulder on whatever branch he may be engaged, as it saves him much trouble and conduces to the production of a better casting. In addition to a good lift it is of great importance that there shonld be a good draw with the pattern. We know of nothing more annoying to the moulder than when, after he has had a clean lift and a well-made parting. he finds a great portion of his mould or parting partially destroyed owing to the circumstance that the pattern has not been properly made to leave the sand, or owing to due provision not having been made to enable the moulder to slacken the pattern in the sand. When this occurs, as is too often the case, the top part should be again tried on before the mould is finished, as in the case of the bad lift. A bad lift, or a bad draw of the pattern, or, as in some instances, both combined, may cause two bad results to the casting—either a part of the mould is crushed, or the casting is found to be marred by a large fin or fins, the latter certainly being the least of the two evils. It is, therefore, very essential that the top part of a mould having deep lifts of sand should be securely staked at the proper places, and that the stakes be of such length as to enable the box to rise perfectly plumb from the parting until it is clear of the pattern. These stakes should be well taken care of, so that nothing may occur to disturb or loosen their

hold of the floor until the box is closed and the job cast. Green-sand moulds are tender to work with, requiring the moulder to be quick of eye, and to possess a firm but gentle hand.

It is usually the case that a good green-sand moulder, when he is called upon to work with loam, becomes a first-class moulder in that kind of work. He has been used to pay more strict attention to the details and minor parts of a mould—he makes better partings, strengthens weak parts with irons, and gives attention to the venting and other matters which the loam moulder would perhaps be disposed to pass over, and lastly, he will finish the mould with better taste, having been used to pay greater attention to these things when he wrought with the sand.

DRY-SAND MOULDING.

Dry-sand castings are always rated higher in price than green-sand ones, and this is only fair, seeing that the former requires fuel and (as a rule) more elaborate provision in moulding; besides, the castings are undoubtedly sounder and cleaner. When they weigh from half a hundredweight up to a ton they are usually cast in two or three boxes, which must fit well and be strong. They are always dried in a stove. When they exceed the weights mentioned they are bedded into the floor and moulded exactly as if in green-sand, and the mould receives its final touches with black-wash just the same as the loam-mould. Dry sand is as near as possible similar to loam, only in such condition that it is fit to be rammed.

The question may here be put—What is the meaning of casting some things in dry-sand and others in green-sand? Could they not all be cast in green-sand, and thus save the expense of drying? We would say—Yes: many that are made could be moulded and cast in green-sand, but the extreme care that would be required in that case, together

with the great liability to mishaps, would far counterbalance the expense of blacking and drying a mould. In many instances it would scarcely be possible to ram a green-sand mould sufficiently to withstand the pressure of the liquid metal. Suppose we take a column, or pipe, nine feet in length, and mould it in green-sand in a two-part box, as it must be cast vertically, what pressure would there be at the bottom of the mould after it was filled with metal ? A column of liquid metal twelve inches in height has a pressure of 3·3 lbs. to the foot, nine times 3·3 are 29·7 lbs., and one foot more for a head would give exactly 33 lbs. pressure on the lowest part of the mould. The pressure quoted being such, green sand cannot bear it with success ; of course the box could be secured with plates, covering all the ramming, so that the sand could not actually be forced out ; but the casting would be swollen into large lumps from the bottom half-way up to the top ; besides, the sand would be eaten into the metal in such-wise that no cleaner could make the casting anything like smooth, and we very much fear that it would be condemned.

Castings that must be clean and sound, such as locomotive cylinders, slide-valves, pumps, &c., also the heavier class of work, such as sole-plates, condensers, &c., are made in dry-sand successfully, and, under certain circumstances, more cheaply than when moulded in loam; they prove as good, and, in some instances, are better castings.

Chaplets of the same kind as in loam are used in dry sand, but when the mould becomes cold they are apt to sink into the sand when the weight upon them is considerable. Columns that are intended for important structures, such as bridges, and to be immersed in water, or high-pressed steam pipes, ought to be cast in dry-sand and run vertically. In this case chaplets are not required, and the core is certain to be in the centre of the casting. For purposes of lesser

importance the work may be cast in green-sand and run horizontally.

In dry-sand, as we have already said, the extra soundness and the greater closeness of the grain, all the properties of the iron remaining combined, give the casting superior strength over those cast in green sand. It seems to us that cast-iron in a liquid state takes more kindly to and rests more easily within this species of mould than it does either in loam or green-sand.

A mould may be built with bricks and loam, and when it has a large and plain surface on the top it could not have a better top part to cover it than one made with dry-sand.

LOAM MOULDING.

Loam moulding stands distinctly apart from either green-sand or dry-sand moulding. The principles of all three systems are, indeed, to a certain extent identical, but the materials employed, as well as the manipulation, are as different as night is from day. By the principles we mean the mode of running, and the plan of venting adopted in loam-moulding, with the use of flow-gates, are as near as may be akin to those employed in sand-moulding.

We have every reason to believe that loam-moulding is the most ancient form or mode of making a mould either for brass or cast-iron. No doubt Hiram, in Solomon's time, was a thorough loam-moulder. We read that his foundry was convenient for getting clay, (1 Kings vii. 46) so that it is more than probable all his heavy work for the Temple at Jerusalem was cast in loam; such as the two great pillars, Jachin and Boaz, the brazen oxen, the molten sea, and the brazen altar. No pattern would be made for such articles as these; in fact, we hear nothing of patterns at all. Hiram would be his own pattern-maker. In this respect some of our modern moulders may have reason to envy Solomon's

founder, as Hiram could have his pattern made exactly to his mind, *i. e.*, to mould. When we come later on, we find that all the heavy bells in China and other parts of the far East were cast in loam, of which there is not the least doubt; so that we are quite justified in saying that loam moulding is the most ancient form of producing a casting.

Of the three branches of moulding the loam is that in which the moulder can best shew his superior ability and genius. He has a broader field in which to exercise his judgment than the sand-moulder, and, this being so, it is hardly fair to say that of necessity he is a superior man to the sand-moulder; by no means—the one has greater scope for his ability than the other.

A loam-moulder may and can make a casting from a complete pattern, part of one, or none at all; and we are safe in saying that the less wood there is about a loam-mould the better, because loam of any sort clings to wood, and therefore when the pattern is drawn out of the mould the surface of the loam presents a great many scales, as it were, and if these are not carefully scraped off the mould the parts of the casting upon which they have been left run a great risk of being scabbed. When the moulder does not take this precaution the metal seldom neglects to take them off for him. This is one of the evils of wood in a loam mould. Another is that when a complete and full pattern is made, the wet loam, coupled with the heat that it gets, and which is necessary to take the mould apart, causes the wood to warp and the joints to open; bye-wood appears here and there, starting and in many cases disturbing the mould, and causing the latter to be torn up on drawing out the pattern. There is yet another evil; should the mould get rather too much fire while the pattern is in it the wood becomes shrunken, the screws and nails lose their hold to a certain extent, and the moisture or glutinous substance from the wood is absorbed by the loam,

causing the mould to be greasy, so that it refuses to absorb the water requisite for the moulder to finish and make it smooth; more especially is this the case when the wood is full of knots; large parts of the loam have then to be scraped off, and new loam substituted. It is a simple and easy thing for a mould that has a pattern in it to get too much heat, even to burning it out, leaving nothing but nails and charcoal. This does not occur often, but we have seen it happen with careful and first-class moulders; therefore, for the reasons we have given, the less wood there is about a loam-mould the better.

Castings of irregular shape, be they large or small, that are made in loam are best cast from a skeleton pattern. The fact of a pattern being properly got up, so that the moulder can make all his internal work, *i.e.*, his cores, and the outside as well, is itself one of the reasons why the cast should be made in loam. This plan takes less time, less wood, and, in short, is not nearly so expensive as the use of a full and complete pattern, with all the core-boxes that it may require.

With a skeleton pattern the moulder is certain of having his proper thicknesses when he comes to close his mould, as the cores are bound to go where they came out of, leaving the space of thickness formed by the wood between them; but this may be saying more than can be depended on when a full and close pattern is wrought from, and the cores made in boxes.

Again, when iron-sand loam is used to make the mould, and the pattern is close and complete, the workman has much extra labour in bringing the mould to a proper degree of smoothness during the course of finishing, because all moulds that are built from a pattern are more or less full of slight hollows, and the skin has then to be broken with coarse rubbers—strong wire carding, from cotton or flax mills. Fine loam must then be applied all over the surface to fill the

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hollows and to make the mould sufficiently smooth. With Erith loam the labour is much less; in fact, it is not to be compared with the work required in sand moulding, owing to the natural fineness of the loam.

It is generally admitted that loam castings are stronger than dry-sand or green-sand castings, dry-sand coming next in strength, the reason of which is, we think, plain—the loam casting becomes annealed in the mould; the loam being a non-conductor of heat to a great extent helps to retain in the iron all its strengthening properties. Dry-sand is next; but in green-sand the iron easily loses its most valuable qualities; the metal is cooled quickly, and in this way the casting becomes weak.

A loam-mould is composed of bricks, loam, and iron, and, for venting purposes, straw or hay and ashes. The ashes may be used, where the building is heavy, for filling up the joints or spaces between the bricks, in the room of wet loam, irrespective of venting, their use being simply to enable the mould to be more easily dried. Old dried loam, or dried sand and rubbish, suit nearly as well when ashes cannot be had. The iron is for the purpose of strengthening the mould, *i. e.*, the bricks and loam.

Loam-moulding seems to be better understood now than it was twenty years since. Better castings are made, and they are executed in a third of the time that used to be occupied with them.

The open sand-bed is closely connected with loam-moulding. It is on this bed of levelled sand that the moulder marks off all his core-irons, building-plates, and bottom or base-plates, as well as the top plates that cover them. Although these castings may be rough, only fit to be hidden away in bricks and loam, and afterwards broken up when the casting is taken from the mould, nevertheless it is extremely necessary, nay it is of vital moment for the safety and success of the casting, that

the irons, plates, &c. connected with and requisite to a loam mould should be carefully marked and lined off on the bed of rough sand; and the moulder should see that they are made up and cast exactly as he has marked them off.

Twenty years ago the loam-moulder had templets, made from thin wood, of all the building-plates and core-irons, to suit the different parts of his mould, but such a thing is not dreamt of now.

The loam-moulder must be able to read drawings or tracings, and from these make everything requisite for the mould, from the base-plate to the top.

It is usually the case that two or more moulders are engaged in working at the same mould, and one of them has what is termed the charge of the job, the others working entirely to his suggestions. It is he who marks off on the sand-bed, and sees that all the plates and irons are cast to his mind, a great deal depending on him for the quick despatch and success of the casting.

When the loam-moulder gets a pattern, or part of one, to make a casting from, he will first consider the best way to mould it. Other factors in the matter, however, have to be considered as well, such as how the pattern is made and the necessity of certain parts of the casting being absolutely clean and sound. These considerations must influence his decision before he settles on the method in which the work is to be moulded; the easiest fashion of moulding may not be the best for the casting, and he cannot go against that consideration. He then considers the cores, how and where they are to be vented—how he is to run the casting—where it is essential to have flow-gates—how the mould is to be bound together—and lastly, how much metal will be required to fill the mould, allowing so much for a head.

All loam-moulds are built upon a bottom plate, which should be made strong enough (two or two and a half inches

in thickness) to be able to carry the mould without giving signs of yielding under the weight; that is, when they are made on the floor and carried by the crane to a bogie for the stove, in order for the mould to be dried. When the mould is large, and the crane not capable of lifting a plate made sufficiently strong to carry it and the mould together, the plate is put into a pit made the proper depth, length, and breadth. A plate to go into a pit need not be cast so thick as one that carries the mould to the stove, because heavy and strong bars are cast five or six inches square (and sometimes more), which are laid in the pit and bedded previous to the plate being laid upon them. These bars are laid at regular intervals, the size of the mould and the opinion of the moulder determining their number. They also form a back-bone to the plate above them, hence there is no necessity for the plate being extra strong; a thickness of two inches is quite enough for the heaviest casting.

The whole mass is bound from these bottom bars to bars running parallel with them above the top plate of the mould, the top ones being much stronger than those below the plate, the latter having the support of hard-rammed sand. A mould of this kind is dried in the pit where it has been built.

We will not specify many particular forms of a loam-mould, but confine ourselves to general remarks on some of the principal items connected with this branch. And seeing that this kind of moulding is so closely allied to marine engine work, we cannot do better than take as an example a bed-plate, or condenser, with pumps, hot well, and columns attached thereto. In this case the moulder first considers the formation of the pattern which is to form the bottom part of his mould, and whether a complete level surface can be made. When the bottom part is of irregular construction, level parts can only be made at intervals to suit, so that the pattern may rest fair and not be twisted. In any case two courses of

bricks, with an inch of facing loam, usually intervene between the plate and the pattern.

When the mould is built with rough iron-sand the first course of bricks is kept wide in the joints, say an inch and a half, and the spaces are filled with ashes. The bricks in the second course are built in the ordinary manner, *i. e.*, inch joints, these are filled with common loam, and the facing loam is then put on. When, however, the bed or bottom part of the mould is made with Erith loam, the second course of bricks is treated in the same way as the first, that is, wide joints and ashes, with the addition of straw or hay profusely scattered previous to the facing loam being put on.

When a complete level bed can be made the pattern may be laid on when the loam is soft; but when only a part or parts of a bed can be made they must be partially dried with fire-lamps, so that the pattern may rest upon without sinking into the loam.

The moulder may be obliged to separate the outside of his mould into many pieces for the purpose of getting the pattern, or what is remaining of it, taken out, and for finishing the different parts; these are termed "drawbacks;" but the more he can keep his mould together the better, as in that case fewer joints are made, the mould is stronger, more able to resist the pressure of the metal, and takes up less room, when parted, on the foundry floor, a matter of some importance when the shop is busy. When the moulder must have drawbacks it is necessary that the different partings should be carefully made and stiffened with hot bricks or sand, so that they may retain their proper formation during the building of the other parts. The loam upon which the drawback-plate is to be laid should be as stiff as is compatible with facility of working. The plate, with its prods or dabbers, must be clean, *i. e.*, free from sand, and no more clay-water than is necessary should be put upon the

plate, as too much softens the loam. Corners which the plate does not reach closely enough should be carefully ironed with three-eighths or half-inch pieces of rod-iron, and the plate should have plenty of holes in it, so that the loam may rise up in them, thus giving the loam an extra hold of the plate. When proper attention is paid to these details a good parting is insured, which makes a speedy and perfect closure. Again, core-irons in a loam mould should not be less than an inch-and-a-half clear of the pattern all round, and carefully packed in the wet loam with dried loam or pieces of brick. In many cases it happens that the heat applied to harden the mould does not reach some of the cores. This packing of the core-irons is to the loam-moulder what the ramming of irons is to the sand-moulder. A little time spent on the packing of core-irons in the heart of a mould is not lost, since the mould can do with less heat; the pattern not being thus endangered, the cores come out clean, and there are no broken-down parts about them; and when they come to be put in their respective places, after the mould is dried and ready for closing, the thicknesses will be all correct. If the moulder fails to do this, either through undue haste or carelessness, the result is sure to be a bad lift with all his cores, requiring them to be mended up, and it takes more time to do this than to treat them properly in the pattern. Unequal thickness is the result of being either too thick or too thin, parts of the cores having to be rubbed off, or, when thicker than they should be, allowed to pass, possibly to the detriment of the casting; besides, it takes one-half longer time to put the mould together under the circumstances we have just mentioned.

IRREGULAR BUILDING OF A MOULD.

In building a loam-mould, of whatever construction it may be, two important things ought to be borne in mind by the moulder; first, the mould must be built so that it may require

as little drying as possible; second, a uniform or regular thickness of loam must be kept on the face of the bricks next the casting, which loam is never to be more than three-quarters of an inch in thickness.

If we consider the moulder building against a pattern, and using an extra quantity of loam to bed the bricks, each brick that he lays down presses out the one that was laid previously; the second course presses out some of the bricks of the first, as they have not stiffened properly in their places, and when the pattern is drawn the surface of the mould will be found to be covered with hollows.

Again, if we consider a mould made without a pattern, the formation of the mould being made with a board cut to the desired shape, and the bricks having in many places to be kept back from the edge of the board, say two inches, such a mould will be full of cracks, and we have already shewn what cracks in the loam do to the casting; besides, the moulder has to wait till the first coating of loam is stiff before he can put on the fine loam to finish with, and when the mould is irregularly built time is wasted in waiting. In irregular building it is just as likely that some parts of the mould may have too little loam on the face of the bricks, and this is a more serious evil than too much.

Let us suppose the case of a large sugar or chemical pan, cast convex side up, in which some of the bricks that form the core of the mould have only three-eighths of an inch of loam on their surface. In this case the casting runs a great risk of being scabbed on those parts where the loam is spare, simply from the want of a body to make it cohere with the joints of loam between the bricks.

When metal falls from a height into a large mould, and some of the bricks on the face of the mould have but little loam, scabbing is sure to follow, unless the loam is extraordinarily good.

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When metal is to fall upon the bed or face of a mould the loam covering the bricks ought to be regular. Where there is a sheet of good loam, three quarters or seven-eighths of an inch thick, properly dried and cast while it retains a little of its heat, it is impossible for a scab to be produced on the casting.

The sides of a mould are less liable to scab from irregular building than the bottom or face, but veins are produced.

The mould should be built regularly on the outside as well as the inside, the building-plates or rings not to be further projecting than the brick-work, and care to be taken that all vent-pipes and fastenings for cores are not flush with the building, as they may inadvertently be made loose in being struck with a rammer whilst the mould is being rammed, or when the mould is not rammed they are liable to accidents.

Loam-moulding is singularly adapted to all kinds of cylindrical bodies, as under this method the mould can be swept up with a board cut exactly as the outside formation of the casting requires. This board is fixed upon an arm coming from an upright bar, termed a "spindle." Two or more arms as the case may be, may be put on the spindle, which revolves in a cast-iron socket, and the arms (sometimes called "shear-irons") are made to slide up or down the spindle. The mould when large is built in a pit, a strong plank or beam stretching over the pit, and having upon it a bush the proper size of the spindle, which is usually three inches in diameter, for the purpose of keeping the top of the spindle steady.

FINISHING THE MOULD.

All loam-moulds or cores made from a board are, after being built up, what is termed "roughed up;" that is, the loam is put upon the face of the bricks, and the board is worked backwards and forwards until the whole mould has

been covered with loam. When iron-sand loam is used it is rough work indeed. After standing some time, and when the board has been made perfectly clean, the loam is "skinned up." When skinned up with iron-sand, or the rough loam already spoken of, the sand is sometimes riddled fine before it is passed into the mill, or the rough-made loam may be passed through a fine riddle, many foundries preferring the latter plan to the former. When the mould is made with Erith loam it is so fine of itself that an extraordinarily fine surface can be brought on the face of the core or mould merely by making the loam soft with water. The board has a bevelled edge, and is kept going one way, the bevel leading. A mould or cores built or made with Erith loam are always finished when still green, with steel tools; loam is easily finished, as great liberty may be taken with it. After being dried—and it can stand great heat, even to being burnt, with comparative impunity—it receives its finishing touches by being rubbed all over with a fine card, when it may be considered ready for the black-wash. It is very difficult to sleek this, on the loam, as it has an inclination to stick to the tools. Many foundries do not sleek their moulds, merely rubbing the blacking parts gently with the hand, or coming over the part with a soft dry brush.

Iron-sand loam is finished after being dried, but, unlike the Erith loam, it is liable to scab when it is burnt. When it has not been skinned up with a board it has to be rubbed all over with coarse carding, then finished with water, fine loam, and finishing-sticks made to suit the different parts of the mould. This is termed "dressing the mould." It takes a long time in many instances, and sometimes much mischief occurs to the casting from imperfect dressing, and the less that a mould receives of the dressing-stick the better; hence the greater need for moulds being swept with a board instead of being built against a pattern, as dressing is not required

when a board has been used. The mould being dressed and cold is now ready for the black-wash, and, unlike the Erith loam-mould, steel or cast-iron tools to sleek the blacking can be used upon it with almost absolute impunity. The loam-mould bears the same relation to the dry-sand as the dry-sand does to the green-sand as regards the freedom that may be taken with it in putting it together. It is strong, and capable of suffering a great deal o rough usage even after it has been finished.

CASTINGS RENT OR SPRUNG.

It is seldom that a green-sand casting is cracked, in fact we may say that we have never known such a case. Dry-sand castings, on the other hand, sometimes crack, and loam castings often. A rent-casting may be caused by, and arises principally from, three things; first, its formation; second, the metal; and third, the manner in which the mould has been built. With the formation or shape of the casting the moulder has nothing to do; but he has to do with the metal and his mould. He knows that his casting must contract in cooling, and if the mould is built strongly and is incapable of yielding to the contraction of the metal, the metal (or casting) must yield to the mould; one of the two must give way. In order, then, to allow the mould to yield, the core-irons ought to have a large amount of clearance from the casting, especially when it is large. We have spoken of an inch-and-a-half of clearance space, but that should only be in small castings; in large ones the clearance should be nothing less than two-and-a-half inches. Again, bricks made of dried loam should be freely used in making the cores where the contraction is great. It is sometimes requisite to build all the cores entirely of loam brick, and to put the same material in many parts of the outside of the mould, such as between brackets, flanges, snugs, &c. Any casting of an inch in

thickness, and of good metal, should be quite capable of overcoming the resistance of a mould built with plenty of loam bricks, and with ample clearance in the core-irons.

We may here mention another preventative; the top of a casting should be a quarter-of-an-inch thicker than the sides, either in dry-sand or loam, the reason being that the metal on the top is not quite so strong and sound as in any other part of the casting, and two causes are at work preventing this from being the case; first, there is less pressure on the top than anywhere else; second, the dust and particles of blacking and loam float to the surface of the mould, and become incorporated with the metal, causing it to be weak. For instance, if we cast an open plate on a bed of sand, say twelve feet by six feet, and two inches thick, and during the time of casting an irruption takes place from some cause, and the metal will not lie at peace—it dances and bubbles as long as it has life—the face of the plate is extensively scabbed—the sand has left its bed to the depth of half-an-inch, possibly more in some places. In nine cases out of ten, when the plate has cooled it will be found to be cracked in the centre; an extensive rent of about four feet may be seen there, the outside remaining quite sound. The cause of this is easily seen—the sand in the centre of the mould has mixed freely with the metal, preventing the cohesive particles from coming together, and in cooling a portion of it parts from the rest. It is customary for smiths who are about to weld two pieces of iron together to throw sand into the fire when the iron is nearly at welding heat; this is done simply for the purpose of causing the silica or cinder to run off the piece of iron about to be joined to another. The smith takes care that no sand is left on his iron, else an imperfect weld is the result. So it is with the plate of cast-iron on the bed, and also with the top of a casting in which there is a large surface. Again, the top of a casting cools much sooner than the sides or

bottom parts, and this of itself calls for the top of all loam castings being made thicker than the sides or bottom parts.

Twenty years since core-irons in loam-moulds were made very strong, and generally cast in the same manner as plates, sometimes so thick as to cause the cleaner to break the castings in the attempt to get them out; the cleaner could not be blamed for this, as the plates were often found to be one-half thicker than the casting; but no such thing as plates are made for core-irons now-a-days unless in very exceptional cases—when they can come out of the casting without requiring to be broken. All core-irons are now made as gratings, easy to be broken, and cast as lightly as possible compatibly with the power to carry the core without giving signs of yielding. In some foundries the plan of easing or slackening the mould soon after being cast prevails to a large extent. Now we do not believe in the expediency of exposing a red-hot casting for this purpose unless under very exceptional circumstances; in fact, we scarcely approve of it at all; for we have known more harm to result from exposing a part or parts of a casting to be eased for contraction than we ever knew to occur when it was left to cool slowly in the mould, assuming the mould to be made for the casting to contract, and the metal good. There are doubtless castings that must be eased, such as large condensers (and the less even they are exposed the better,) and large columns or cylinders for bridge work or colliery shafts. These have to be eased because in their case the core may be said to be an iron core, covered with two inches of loam. This iron core is cast in segments, one of which is V-shaped, so as to be easily drawn in, and the rest of the segments follow. A foundry on the Tyne casts two of these in the week, eighteen feet in diameter, seven feet deep, and twelve tons in weight. In this case the casting must be eased, and the iron core with

its coating suits the purpose well; but this is a speciality, and arrangements are made to suit it.

Some foundries slacken all their cylinders for marine work, or land engines. This we consider to be a great mistake. It is some years since the writer saw the folly of such a practice. He once wrought in a shop where every cylinder had to be turned on its side the day after being cast. The main core was then taken out, and the core in the steam-chest partially removed. As the result one cylinder was cast too heavy for the crane to turn it over; it had to cool without being eased, and no harm came of it. We reasoned, then, that if a large casting could cool in its mould and no harm take place, so could a small one. Again, what further convinced us of the impolicy of exposing hot castings was this—There came to a shop where we once wrought a cylinder pattern for a marine engine; no time was to be lost in making it, as it had been previously three times badly made in two different foundries. We learned that it had cracked in each case, although it had been carefully eased on the day following the process of casting. It was, therefore, decided in our foundry not to ease it at all—give the core-irons plenty of clearance—use plenty of loam bricks in the cores, and let the cylinder stand for a week after being cast. The result was a great success. We have acted on that plan ever since, and believe it to be the right one. The above-mentioned casting, we may note, was upwards of ten tons in weight.

CLOSING THE MOULD.

The moulder in charge of a loam-mould should look forward to the day on which he intends to begin putting his mould together—see that all his small cores are prepared, that the chaplets which he may need are all ready to lay his hands upon, as well as tubes for his vents, bolts and washers to secure his cores, and a thickness-stick by which to set them.

If he has all these smaller things ready there will be no fear for the larger ones.

The duties of a chargeman on the day of closing are very important; first, he should not be absent on the morning when he has to close; he should be seldom or never away from the mould during the day, so as to ensure that everything is at hand and ready; he should note carefully all the thicknesses—see every core resting properly—notice particularly that no crushes of the mould in any part take place—himself make up all important vents—if a core does not suit well be quick in deciding what is to be done with it, and never cause a core to be slung on the crane unless he is quite ready to lower it in its place at once, as some one else may require the crane. When a core requires to be altered, either by rubbing a piece off or putting more material on, lower it off the crane, whether any other person may be wanting the latter or not; if no one wants the crane cause another core to be slung up, and go on with the closing. See that the labourer has always plenty of hot plates in a fire close at hand, so that handles, or rather holes in the core, caused by the lifters, may be dried at once when made up. These things, if strictly attended to, must cause the mould to be speedily put together, which is the life of a casting, in whatever loam it may be made. We may say, further, that if the chargeman has any doubt about anything he should act at once, so that no doubt shall remain; if he is not sure of something, then he should make it sure; doing so may save him many difficulties afterwards.

Where ordinary chaplets are required to rest cores upon great care must be taken to see that none of them are too full in size, as the weight of the core, or the binding that follows, may cause one of them to crush a portion of the core, causing at once a bad casting; and the same careful watching must be observed in using chaplets as is requisite

to keep down cores. To find the proper thickness on the top of a core, that is, the thickness intervening between it and the top plate, it is customary to lay pieces of clay on the top of the cores, as many pieces, and on the proper places, as the moulder or chargeman may in his discretion think fit. The chaplets are then put on to the exact thickness of the clay. Chaplets are made to advance in eighth parts in size. Where they are found to be a sixteenth lower or thinner than the clay, a slip of hoop iron the exact length of the chaplet is laid below it. When the chaplet is a sixteenth-of-an-inch too thick or too high it is rubbed down into the core until it suits the clay. Many castings have been and are lost from a chaplet being too keenly set in the mould, the binding together of the mould having completed the mischief by causing a portion of the core to be crushed.

RAMMING LOAM MOULDS WITH SAND.

Should loam moulds be rammed up ? This question can only be asked and answered from an economical point of view. The ramming of the mould means the filling up with sand of the space that intervenes between the outside of the mould and the sides of the pit—generally two feet, this being done by labourers. The sand is rammed with flat or dog rammers, and in courses of twelve inches deep at a time, until the top of the mould is reached. When the casting is heavy and the mould deep, the ramming must be made very hard, care being taken that no rammer is allowed to strike any part of the mould. Many foundries are in the habit of moulding their heaviest castings, even up to the weight of twenty tons, without ramming ; but is it done as cheaply or as successfully as it would be if ramming were resorted to ? If we consider the extra provision and the elaborate appliances which are requisite when moulds are not rammed to sustain the pressure of metal and expansion of the mould by

heat, we must come to the conclusion that ramming up with sand is the most natural and the cheapest method, except in special cases, or where a great many castings are wanted from one pattern ; then, indeed, it pays the moulder to provide proper mechanism and appliances to do it without the aid of unskilled labour, and thus dispense with ramming.

A loam-mould that is to be rammed up with sand in a pit has simply a plain building-plate three-quarters-of-an-inch thick, on every three or four courses of bricks, and of the breadth of the building, which is usually nine inches. This is done to make the building strong and compact. A loam-mould that is to be cast without ramming in the pit will have a building-plate on every two courses of bricks, made two inches broader than the outside of the building, with flat prods or dabbers cast on the outside edge of each, nine inches in length, so that the building-plates will rest on each other. In this way a strong iron cage surrounds the whole mould. But this is not sufficient : the bottom plate upon which the mould is built must be one-half stronger than the one that is to be rammed up, and it must have large open snugs cast at intervals of say two feet apart ; these square holes in the snugs are to admit a strong cast-iron bar, say five inches square ; the top plate covering the mould must have snugs similar to the bottom ones, and like the bottom plate in strength. When the mould is closed the bars are lowered into the snugs, the bars passing through the bottom plate ; cottars are then passed top and bottom through the bars, holes in them being provided for the purpose, and the top and bottom are in this way bound together. But the binding of the mould is not even yet complete ; every building ring or plate has to be carefully stayed opposite to the vertical bars ; every joint in the mould must be covered with a plate made for the purpose, and bedded with soft loam, and then stayed from the bars. The binding bars on the top are clamped to

the top-plate snugs. It is this elaborate arrangement, necessitating the use of an enormous quantity of cast-iron for binding purposes, that constitutes the principal objection to moulds being cast without also being rammed. The danger of losing the casting is also great in such a case. When a mould secured in this manner is filled with metal, should there come forth the smallest running of iron from any place that has not been properly secured it can seldom be stopped. On the other hand, when the pit is rammed with sand, and metal find its way out from a joint, it seldom runs far. We may say that the vents come more freely from a mould that is not rammed with sand than from one that has been so rammed.

A loam-mould being filled with liquid metal has something else to contend with besides the actual pressure; the bare pressure may be only thirty lbs. on the square inch on the lowest part, but the mould has also to withstand the sudden expansion of the metal by heat, and that is in nearly every case of greater moment to the moulder than the actual pressure. As a proof of this, a mould never gives way during the process of filling. But when it is filled the ladle or ladles may be turned back to their right position, the moulder may be about to thrust his feeding-rod into the metal, the other men who have been assisting are about to retire, thinking that all is right—when suddenly the earth opens—a blue flame is emitted in a long line, quickly followed by a thin sheet of liquid metal, and the mould is found to have given way. Given way to what? it may be asked. Not to the pressure of metal, for it carried that safely enough. What then was the cause? The answer is, that the mould was quite adequate to sustain the pressure of metal, but could not withstand the expansive force of the heat. But it may again be asked—Why do some foundries produce all their castings—and heavy ones too—without ramming them

up with sand ? We answer, it is a custom in these particular foundries, owing to the belief that it can be done with more economy than when labourers are employed to ram up a pit.

We know there are many castings made in loam that can be and are produced with perfect safety, and more cheaply, without being rammed up, and these not specialities by any means. Among them may be mentioned propellers, pipes, columns, internal shells for cylinders, cylinder covers, pistons, junk, and packing rings. These do not require such an elaborate or expensive get-up as many other castings do when they are not rammed. It may be said that to ram up a mould you require more labourers than when the mould is not rammed, and that therefore more expense is entailed by the former method. Now, it is quite true that more labourers are required to ram, but then they can be so utilized as to be made to do what moulders paid double their wages would require to do in lieu of ramming. Thus the two methods are about equal as regards expense ; besides, the labourers, when not ramming a mould, are spread over the shop, keeping it in order, and furthering the onward progress of moulds in many ways. Some employers imagine that labourers are non-producers, and do not like them ; but when we consider how much they can really save the moulder by leaving him free to devote his whole attention to moulding, we must confess that the labourer is an acquisition, provided always that no more of them are employed than are really required.

We may notice here that loam-moulds which are made with Erith loam are usually built with fire-clay bricks ; they suit this kind of loam better than common bricks, and we believe they are more economical, standing the heat better, and not breaking up into so much refuse as common clay bricks do. Iron-sharp-sand loam clings better, and has a

closer affinity to common clay bricks than any other kind, the clay in the loam no doubt causing this; hence, the common red clay bricks are used with this kind of loam.

MAKING THE HEADS.

Making up the heads or gutters to receive the metal from the ladle, either in green-sand, dry-sand, or loam, is a most important matter, more especially in the latter case, as the heads are generally much more extensive in loam than in the other two branches, owing to the castings being usually larger. It often occurs that this part of the process of moulding is done hurriedly; indeed we may safely say that this is so in nine cases out of twelve. It seems to be taken for granted by most moulders that when the last part of the mould is closed and hidden from sight little else remains to be done. "Bring the metal forward" is often the order of the day, too frequently resulting in a scrimmage to get the heads ready; but anything hurriedly done is never well done. When a ladle of four tons or up to ten tons is required to fill a mould with metal the basin should be large and capacious, nothing less than three feet in width and twelve inches at its outlet. It should be made of dried loam, in preference to being of sand, as many good moulds have been ruined by the heavy wash of the metal raising up the sand that formed the bed of the basin. With a well-dried loam basin this cannot occur.

The gutters that lead from the basin and are intended to communicate with and connect all the little gates that are attached to, or rather open into, the mould, should not be less than nine inches deep, by six inches broad; they should be formed of good sand, free from scrap iron, and the bottom of the gutters ought to be twelve inches above the casting. The gutters should be so formed, or rather planned, that an equal distribution of the metal leaving the basin may be had all

over. For this purpose the basin ought to be set as near as possible to the centre of the place where the gutters are to be cut out. When this is not attended to many parts of the gutters do not get enough of metal to supply the gates in those parts, scum and dirt rushing in with the metal, while other parts may be overflowing. The gutters should be as clean as the inside of the mould they cover, carefully firmed up with the hand, and with no loose sand on sides or bottom. The flow-gates should be well protected from metal running into them in case of an overflow, owing to the ladle being too much turned, or (as is the case with some ladles) taking a sudden lurch and thereby throwing more metal out than the gates are adequate to take in. A little bank of sand three or four inches round each flow-gate will protect them. The character of a moulder, as far as his workmanship is concerned, can always be known from his manner of forming his heads and the pains he takes in securing their cleanness. Many moulds have been well enough made, and yet the casting has been lost through imperfectly and hurriedly made-up heads. Notably, castings that are to be turned or bored must suffer from what we term a dirty cast, the natural result of badly-made and dirty heads. The moulder should easily know, from what his furnace can do, when his ladle or ladles will be filled, and the metal should be subservient to the mould, not the mould to the metal. Better that the mould should be ready for half-a-day than that the metal should wait in the ladles for half-an-hour.

THE COMPOSITION OF CAST-IRON.

Mr. Bloxham, the great authority on cast-iron, says:—"Carbon is invariably and indispensably associated with cast-iron, so that the latter sometimes has been spoken of as a carbide or carburet of iron; but this would convey the impression that the whole of the iron present existed in chemical

combination with the carbon, exactly as in the oxide of iron the whole of the iron is combined with oxygen; whereas the greater part of the iron in cast-iron is present in the uncombined state, its properties being altered or modified by the presence of the carbide of iron, or compound of carbon with iron, which is diffused through the metal. But for the circumstance that the term "alloy" is conventionally restricted to the substances formed by the alliance of metals with each other, whilst carbon is a non-metallic body, cast-iron might be appropriately designated an alloy of iron with carbon. The proportion of carbon present in cast-iron varies in different samples, but it never amounts to five per cent., so that the carbide of iron must be regarded as being in a state of intimate mixture with metallic iron."

"On examining the fracture of freshly-broken pig-iron it will be found that some specimens have a silvery-white and others a grey colour, caused by the presence of very minute particles of carbon which are interspersed among the light-coloured particles of the metal. This sample acted upon by certain acids dissolves the iron, but leaves the carbon, whereas in white cast iron, very little carbon is left."

"When a sample of grey iron is melted the particles of free carbon are dissolved by the liquid metal becoming chemically combined with a portion of the iron, and if the melted mass be suddenly chilled by throwing water upon it, or by running into a thick iron mould, the carbon does not separate again, so that a mass of white iron is produced. It is more difficult to convert the white into the grey variety of cast-iron, but this has been effected by exposing the melted metal to a high temperature, and allowing it to cool slowly, when a portion of the carbon separated from the iron, and the grey variety of cast-iron was produced."

Every moulder knows that he can produce any desired portion of his casting nearly white, and extremely hard and

brittle, by making use of the chill; for instance, the heads of shot and shell, the faces of forge-hammers, &c.

Mr. Bloxham says further, that "since in grey cast-iron a smaller proportion of the iron is in combination with carbon and more of it in the true metallic state, this variety would be expected to exhibit more of the properties of metallic iron, whilst white iron ought to present the characters of the chemical compound of carbon with iron described above. Accordingly the grey cast-iron is much softer than white iron, and admits of being filed and turned, whereas the white iron is so extremely hard that a file will scarcely touch it, and a blow from a hammer which indents a pig of grey iron will easily break one of white. The larger proportion of metallic iron contained in the grey cast-iron causes it to require a higher degree of heat before it begins to exhibit signs of fusion; but it is capable of becoming very liquid at a sufficiently high temperature, so as to be easily run into moulds."

"White cast-iron, on the other hand, is softened at a rather lower temperature, but does not flow well, assuming a greasy or pasty consistence. It scintillates or throws off sparks, commonly termed by moulders "jumpers," to a much greater extent than grey iron, as it runs from the furnace. White cast-iron is about a twentieth part heavier than the grey variety, its average specific gravity being 7·5, whilst that of grey is 7·1. The grey iron rusts more easily in air, and is more readily acted upon by acids than white iron, which circumstance may be ascribed partly to its containing more iron in an uncombined form, and partly to the acceleration of chemical action caused by the voltaic disturbance excited by the contact of the particles of carbon with the particles of iron in the presence of the acid, which in the case of air is carbonic acid."

"White iron usually, but by no means invariably, contains less carbon than grey iron. Mottled cast-iron is

composed of a mixture of the grey and white varieties in varying proportions, the grey iron sometimes appearing in specks like minute flowers upon a white ground, whilst in other specimens the mass is composed of grey iron, and the white iron appears in spots."

Bloxham says again that "the tenacity of cast-iron is found to be increased by re-melting." On this point we differ from him. He does not seem very clear on the reason why it should be so: he only gives a probable cause. We hold that cast-iron after the second melting loses its tenacity and a great deal of its character for softness. We believe that the frequent re-melting of cast-iron would ultimately reduce it to white iron. However, Mr. Bloxham is evidently fully conversant with the nature of cast-iron, and we will see what he further says on this important subject—important alike to the moulder and to the engineer.

"Next to the carbon, silicon (or silicium) is the commonest and most abundant constituent of cast-iron, its quantity varying from $\frac{1}{1200}$th part to nearly $\frac{1}{20}$th of the weight of the metal, the proportion being higher in the grey than in the white. The silicon appears to exist in a state of chemical combination with the iron, and is derived from the silica in the ore or in the fuel. Silica is a combination of silicon with oxygen; and when the latter is abstracted by the carbon at the high temperature of the blast furnace the silicon enters into combination with the iron. The presence of a large proportion of silicon in cast-iron is generally regarded as injurious to its quality, the strongest iron being that which contains a small quantity of that element. Iron which has been smelted with coke contains a larger proportion of silicon than that smelted with charcoal; and hot-blast iron contains more than that smelted by cold-blast."

"Manganese is seldom if ever absent from cast-iron, for it is a metal which very nearly resembles iron in its chemical pro-

perties, and is commonly found in iron ores, so that the same operation which reduces the iron in the blast furnace also reduces the manganese, and this metal becomes alloyed or intimately mixed with the melted iron. The manganese has been found in the large proportion of $\frac{1}{16}$th of the weight of cast-iron, but it seldom exceeds $\frac{1}{40}$th. The influence exerted by manganese upon the character of cast-iron is very decided, tending to the production of the white variety, as it will not let the carbon separate. White iron, therefore, contains the largest proportion of manganese. It has been asserted that the presence of manganese in iron ores encourages the passage of sulphur and silicon into the slag, thus reducing the proportion of those injurious impurities in the metal."

"Phosphorus occasionally forms between $\frac{1}{50}$th and $\frac{1}{60}$th parts of the weight of cast-iron, but $\frac{1}{100}$th part is a common proportion of phosphorus. It exists in chemical combination with a portion of the metal as phosphide of iron contained in the ore, and is derived either from phosphate of iron contained in the ore, or from phosphate of lime, which is frequently present in the limestone, employed as a flux, and in minute quantity in the coal. These phosphates contain phosphorus in a state of combination with oxygen, which is abstracted by the carbon of the fuel in the blast-furnace, and the phosphorus thus set free enters into combination with the iron. So completely is the phosphorus taken up by the metal that only traces of the element in the form of phosphates are usually found in the slag from the blast-furnace. The effects of phosphorus are to harden the cast-iron and to increase its fusibility."

"Sulphur, though almost invariably contained in cast-iron, rarely forms as much as $\frac{1}{50}$th of the weight. It may be derived from iron pyrites contained in the ore, or in the coal. The white varieties of cast-iron contain a larger proportion of sulphur than the grey, and it is generally admitted that

the presence of sulphur diminishes the strength of cast-iron in a very high degree."

We append Mr. Bloxham's table, illustrating the general composition of the three principal species of iron in use at foundries :—

	GREY.	MOTTLED.	WHITE.
Iron	90·24	89·31	89·86
Combined Carbon	1·02	1·79	2·46
Graphite	2·64	1·11	0·87
Silicon	3·06	2·17	1·12
Sulphur	1·14	1·48	2·52
Phosphorus	0·39	1·17	0·91
Manganese	0·38	1·60	2·72

This table may be of great interest to the moulder, and not only to him, but to the engineer. Rarely does it occur that the moulder has the time or means and education to enable him to pursue the study of, or even enquire into, the chemical properties of the material which passes through his hands every day in the shape of pig-iron. It may appear at first sight strange, but is none the less true, that engineers as a rule are equally ignorant with moulders of the component parts of cast-iron. Many engineers could not tell the difference between No. 1 and Nos. 3 or 4, or cold-blast from hot, yet cast-iron forms by far the greatest part of an engine.

Nos. 1, 2, and 3 are grey irons, No. 1 being a shade darker than the others, and shewing a more crystalline appearance on the broken surface. No. 1 is principally used for fine castings, as it becomes more liquid than any other, and can run castings of the frailest and finest construction. Nos. 2, 3, and 4 are used more for ordinary castings. When different brands of No. 3 are mixed in proper proportions, a strong iron is produced, with a third of good clean scrap, but not wrought iron scrap, as Bloxham says. We never knew wrought iron scrap to be put in a cupola and melted with the cast iron ; the great

heat requisite for the melting of cast iron would in all probability entirely change the character of the wrought iron. We have known of malleable turnings being put into the ladle and melted there immediately before casting; this being done at the instigation of the engineer for whom the casting was intended, but we could never learn that the casting was any stronger for it; but one thing we know, that it changes the character of the metal very much, by making it lazy to run; consequently the casting incurs the risk of some part of it being cold-shot.

Bloxham further says :—"The average tensile strain of cast-iron is about seven tons per square inch. The general brands of iron in use in foundries are Nos. 1, 2, and 3, sometimes 4 and 8 for certain castings, No. 4 best grey forge iron, and No. 5 grey forge: they do not become so liquid when melted as 1, 2, and 3; but they are tougher and better fitted for purposes where strength is required. No. 5 is also used for the manufacture of wrought-iron, as is also No. 6, or strong forge, which is still less grey in quality. No. 7 is decidedly mottled iron, and No. 8 is white. Grey cast-iron is usually regarded as the proper or normal product of a blast-furnace in good working order, supplied with a due proportion of fuel. If the quantity of fuel employed be too small for the ore, so that the temperature is low, a white cast-iron is produced, and a large proportion of iron is found in the slag, to which it imparts a nearly black colour. The slag from a furnace yielding white iron contains about five per cent. of the metal, whilst the slag from grey seldom contains more than two per cent."

"When the proportion of sulphur in the fuel is large the iron will tend to be white, unless a heavy charge of limestone is used."

"Cold-blast iron is stronger and purer than hot-blast, being freer from sulphur and phosphorus, the temperature of

the cold-blast not being adequate to melt the same kind of charges that are put into the hot-blast. Cold-blast iron is usually melted from ore only, whereas in the hot-blast it is not uncommon to use one-fourth of the charge from cinder-iron, taken from the puddling-furnace, this producing sulphur and phosphorus."

The different kinds of iron present different phenomena in flowing out of the furnace, more decided from the smelting furnace than from the cupola, but still the same, only in a lesser degree. The moulder will have noticed that when No. 1 or grey iron is running from the cupola into the ladle very few sparks are thrown off, and those only fall as ordinary sparks. Very different are the sparks or jumpers that are thrown off from No. 4. In the first place, there are four times more, the greater number arising from a cause quite different from that which exists in the former case. Tomlinson explains this in the following words:—"From all parts of the fluid surface is thrown off a vast number of metallic sparks, from the absence of carbon, which renders the metal sensitive to the oxidising influence of the atmospheric air. Small spherules of iron are ejected from all parts of the surface to the height of five or six feet, and sometimes higher, when they inflame and separate with a slight hissing noise or explosion into a great many particles of brilliant fire, forming oxide of iron."

No. 4 iron when in the ladle shews a greasy appearance, with scarcely a break on the surface, whilst the act of raking the rubbish off it separates it, as it were, into long cuts, as if it had a scum on the top, presenting a dull and lazy appearance. When small castings for engine work are made with this iron, on the surface of the castings being planed or turned, they will seem as if worms had been making their bed in the metal, the latter being full of clear worm-holes.

No. 1, on the other hand, presents quite a different aspect in the ladle. Mr. Mushet describes it thus :—" Millions of the finest undulations move upon the surface, displaying the greatest nicety and rapidity of movement, conjoined with an uncommonly beautiful variation of colour, which language is inadequate justly to describe. Such metal in quantity will remain fluid for twenty minutes after it is run from the furnace, and when cold will have its surface covered with the beautiful carburet of iron already mentioned, of an uncommonly rich and brilliant appearance." It should be understood that Mr. Mushet is here speaking of the appearance presented by the iron on its coming from the smelting furnace, although it presents exactly the same appearance when run from the cupola. In the ladle every moulder can easily distinguish No. 1 from No. 3.

The appearance of No. 2 and No. 3 in a state of fusion presents some of the phenomena both of No. 1 and of No. 4. The slag from No. 3 or No. 4 is slightly different from that of No. 1, or fine grey. In cupolas in which slag-holes are used the difference will very often be noticed in the following manner :—In No. 3 or No. 4, after the cupola has discharged nearly all its slag, the blast will impel the remainder with such velocity as to blow the slag into minute fibres smaller than the most ductile thread, or rather wire. At first these float upon the air like wool, and when at rest they very much resemble that substance. This never takes place with No. 1 or fine iron.

These remarks on cast-iron are fully borne out by Tomlinson in his *Cyclopœdia of Useful Arts*, by Percy's *Metallurgy*, and by Bloxham *On Cast Iron*.

We shall now specify a few mixtures of different kinds of iron for various castings, as we have seen them proved in actual practice.

MIXTURES OF CAST IRON FOR CERTAIN KINDS OF CASTINGS.

A good tough iron for locomotive cylinders may be thus composed :—No. 4 Pontypool Welsh cold-blast, one-half ; No. 4 Clyde, one-half ; melted and cast into pigs for the purpose of being properly mixed. If the cylinders are above an inch thick, mix two parts of No. 4 Clyde with one part of No. 4 Pontypool.

For ordinary marine cylinders No. 3 Clyde, Coltness, Summerlee, and Monkland, equal parts, with five cwt. of good clean scrap to the ton ; if no scrap, about four cwt. to the ton of No. 4 Clyde, which makes a good close and tough iron. When plenty of good clean scrap can be had, the following alternative mixture will be found equally good, and will melt more quickly :—Seven cwt. of Summerlee, Gartsherrie, and Carnbroe, equal parts, four cwt. of Weardale or Middlesbro', and nine cwt. of scrap. This mixture does well enough for bed-plates. For propellers one part of hematite No. 4 and two parts of as many brands of No. 3 as possible, say the same as last, or two parts of good clean scrap, make an extremely tough iron, one inch square bar of iron, three feet in length bearing, breaking at eight-and-half cwt., $\frac{1}{10}$ths deflection.

Anvils and hammers for forges :—Five cwt. No. 4 Pontypool, five cwt. No. 3 hematite, five cwt. No. 4 Clyde, and five cwt. Monkland white or No. 8. This mixture is extremely tough and very hard.

Light work, not ornamental :—Three or four brands of No. 3 G. M. B, and about five cwt. to the ton of No. 1 Gartsherrie or Coltness.

Internal shells for H. P. cylinders :—Three cwt. of white, three of Summerlee, and two of Middlesbro', to the ton, the

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rest good clean hard scrap, cast into pigs, the same as the locomotive mixture ; if no scrap, four cwt. of white to sixteen cwt. of mixed brands No. 3.

Another good mixture for ordinary green-sand castings, and when the scrap is good and plentiful, is :—Four cwt. of Scotch M. B, six cwt. of Weardale, and ten cwt. of scrap. When the scrap is good, such as old engine iron, or used-up plates from foundries, this mixture will be found not to be far behind any of those previously quoted. It will bear a strain of 7½ cwt. on a three-feet bar one inch square $\frac{11}{16}$ths deflection.

THE CUPOLA AND AIR FURNACE.

Like many other things, the cupola has undergone a great many changes within the last twenty years. A good quickly-melting cupola is of great importance to the moulder as upon it depends in a great measure the success of many important castings. Foundries have also extended in the matters of number and size, improved forms, and steam or hydraulic cranes ; all to meet the increased demand for castings of a heavy class, so that naturally the cupola, being of such importance in the foundry, has come in for its share of improvement. A moulder is proud of his cupola if it is a good one, and when a stranger comes into the foundry the moulder will not be long in shewing the cupola to him, pointing to it with pardonable pride, and saying, "That is our cupola, we melt so many tons in an hour with so much coke and so many ounces of pressure." We never yet went into a foundry without being shewn the cupola, and had to to listen to the story of its qualifications. When a moulder knows that his cupola can supply him on demand with twenty tons of metal in good condition to cast in one casting without any or little trouble, he has some reason to be proud of it.

Although cupolas have been improved, the principle remains the same as it existed in the days of Tubal-Cain. In India and Asia, at the present day, the natives may be seen on the road-side working at a charcoal fire below a rudely-made crucible, and a still more rudely-made pair of bellows which have been manufactured from some beast's skin, blowing away and melting metal. That is their cupola, and they can barely melt ten ounces in an hour. We can melt upwards of ten tons in the same time, but the principle is the same in both cases.

CUPOLAS.

The early cupolas in this country were of a rectangular shape; then followed the round form, which is still retained. The first round cupolas were very short and wide, deriving the blast from common fans; the distance from the bottom to the tuyere did not exceed two feet; they seem to have had two rows of tuyeres, the top one about twelve inches from the under, the intention of this being to stop up the lower tuyeres when the metal appeared, and to blow from the top ones. The distance from these to the top, or rather to the charging door, was four or five feet.

But strong and brisk competition in foundries demanded a change, and the problem to solve was the invention of a cupola that would melt quickly with the least consumption of fuel. This resulted, as Spretson says in his "*Casting and Founding*," in the invention of five different formations of cupola, namely, Kirkgar's (German); Mackenzie's (much in vogue in America, as the anthracite coal suits it best); Ireland's; Woodward's steam-jet, and Voisin's.

The best of these, in our opinion, is the Kirkgar cupola, its interior formation being best adapted for melting a large quantity of metal. Spretson gives the dimensions of such a cupola as follows:—

	feet	in.
Diameter at hearth	3	3
,, ,, charging door	3	0
,, ,, top of chimney	2	6
Height from base-sill to charging door	7	0
,, ,, from door-sill to top of chimney	16	0

It will be seen from the above that this cupola is larger at the base than at any other part, slightly tapering to the charging door, so as, in a great measure, to prevent the charges hanging above the tuyeres. The other descriptions of cupolas given by Spretson are, in our opinion, calculated to encourage the charge to hang, being narrow from the base up to a little above the tuyeres. then getting wider up to the charging door. Of course the object in cupolas of this formation is to save fuel before charging with iron ; but we think the advantage thus gained is not to be compared with the disadvantage of the trouble and risk involved in hanging and scaffolding. The latter must take place in cupolas of this formation to a greater or lesser extent at the end of two hours' blowing, and the avoidance of scaffolding in a cupola is a most important desideratum. We may here explain the cause and effects of scaffolding, which we hold takes place, as a natural consequence, in every cupola, more or less, of whatever formation.

We will suppose a cupola to be charged with pig-iron and clean scrap, or wholly with pig-iron ; the blast is put on ; in ten or fifteen minutes the metal will be seen, on looking in at the tuyeres, to be dropping or running in little rills, the coke close to the tuyeres being in a state of bright white heat, so white indeed that a practised eye can only see the metal running. After an hour has passed, look in again at the tuyeres, and something else than metal will be seen dropping and running, that is slag. It will serve no useful purpose for us to give the chemical properties of this slag, as it is well

known that the iron, lime, and coke all tend to form a body known by the moulder as slag. The cold air rushing from the tuyeres blows this slag on to the coke nearest the tuyere; the slag at once becomes black; the metal running is blown upon the black slag and immediately sets; the coke that has retained this slag and metal becomes cold, and more and more is accumulated until the whole surface is black and cold. This at first forms only a thin partition, as it were, between the blast and the bright fuel, a light pricker easily breaking it down and allowing free access to the air again; but after some hours, say four, it will be found to have become very strong, so strong indeed that it will require a steel bar driven into it with considerable force to break it through; then it will be found to extend some distance towards the centre of the cupola, and to have become a mass of cold coke, slag, and metal. This taking place with three tuyeres in a cupola three feet six inches in diameter may soon only leave a space of eighteen inches clear in the centre. The furnace has then become "scaffolded," and begins to melt very slowly, therefore the sooner it is drawn the better, a strong partition having been formed between the blast and the charges.

We have spoken here of the worst kind of scaffolding; seldom does it occur in so bad a degree as this unless the iron be very dirty, the coke dirty also, and the tuyeres not properly seen to. However, as we have said already, there is now no cupola in use which will not shew, at the end of four hours' melting, more or less symptoms of threatening to "scaffold." We must, then, consider the best means to prevent "scaffolding." This, we have found, is to cease blowing with one of the tuyeres, and build the tuyere up with chips of brick and loam. In about a quarter-of-an-hour the salamander will be found to have disappeared. Or, when the tuyere is beginning to shew signs of getting black, a few pieces of small coal pushed into the face of the tuyere will be

of much service, if they can be got to catch fire; if not, the coal is of no avail. Completely stopping up one of the tuyeres in turn never fails, and the cupola can be kept in good order for many hours.

The best form of cupola is, to some extent, a matter of opinion. The view that we have formed is, after no small experience, that the cupola works best when parallel from the bottom to the charging door. One of four feet diameter should gradually close in from the charging door to the top of the chimney to the diameter of three feet, and should not be less in height from the bottom to the charging door than thirteen or fourteen feet, and sixteen feet if appliances are easily available for lifting the charge up to the stage. The height of the chimney is of no importance so long as it is kept clear of the foundry roof.

A cupola of this plain formation, with three tuyeres seven inches diameter each, supplied with a blast pressure equal to twelve inches of water, or eight ounces, will melt twenty-eight tons of clean iron in four hours; one-and-three-quarters cwt. of good coke to each charge of twenty-three cwt. of iron.

A small cupola, eighteen inches diameter at the base, and twenty-two inches at the charging door, twelve feet from the base to the charging door, and two feet from the bottom, to three tuyeres of three inches diameter each, will easily melt one ton per hour, the charges being forty lbs. of coke to five cwt. of iron, one-third being pig-iron, the blast being the same pressure as quoted above.

One of the same kind as the above, only six inches larger in diameter, will easily melt one ton and a half in the hour, the charge of iron being increased to seven cwt., with forty lbs. of coke, the same as the smaller one; the metal from both cupolas being quite adequate to run grate metal castings. These results are equal to those of any cupolas of which we know.

Woodward's steam-jet cupola acts very well; but we do not think that it will ever become popular. The inventor claims for it a saving of fuel; but from what we can learn—and in one that we have seen in use—the saving is obtained at the expense of slowness in melting and dulness in iron, two very important considerations with regard to a cupola; possibly it had not been wrought exactly to the inventor's idea. No blast is required for this cupola, the steam-jet in the chimney being in its stead, so as to produce a sufficient current or column of air.

Voisin's cupola is distinguished by a falling bottom, after the American plan, and by the manner he has arranged the tuyeres, which we consider a good plan, in preventing to some extent "scaffolding." The falling bottom, we are inclined to think, will never be much in use unless with small cupolas. This cupola is narrow at the boshes, an arrangement we do not like. The next trouble in connection with the cupola forming carbonic oxide—commonly known as "scaffolding"—is the hanging of the charge; sometimes, indeed, this tends to produce the former evil. The furnace-man is much to blame when a charge hangs, as he has caused the mischief by either leaving projections of brick sticking out when repairing the lining, or by carelessly throwing in the metal when in the act of charging, the iron becoming wedged between the sides, the charge refusing to sink gradually as it should do; as the charges lower down gradually get melted, a sudden fall of sometimes eighteen inches is thus caused. Broken plates that have been used for loam work, with stout long prods, inadvertently catching the rough sides of the cupola, will easily cause the charge to hang; but the man who is charging should be alive to that danger, and endeavour to place his iron so as to prevent its catching the sides or walls of the furnace.

Cupolas that have a belt running round them, for the blast

to enter at the tuyeres, ought to have a large sliding door provided in the belt opposite the tuyere, nine inches by twelve; this door will enable the cupola-man to close up any tuyere when necessary. A small spy-hole in the centre of the door will enable the state of the tuyere to be ascertained at any time without the slide being moved; but when tuyeres keep fairly clear of themselves we think it is best not to touch them.

CHARGING THE CUPOLA.

The cupola is generally lighted three hours before the time appointed for blowing, as much coke being put in as shall reach fifteen or eighteen inches above the tuyeres. When the fire reaches the tuyeres and is fully developed, the furnace can be charged with metal. Should there be an eddy wind the fire may take an hour longer to kindle up to the required height, and in that case the cupola (for that cast) will not melt so quickly. A long chimney would tend greatly to counteract the effects of a down-blowing or eddy wind. The furnace-man is generally the best judge of the proportionate weights of iron and coke that his cupola can properly take for a charge. For cupolas in every-day use in ordinary jobbing foundries the charge of iron is about twenty-four cwt. of metal to one-and-a-half cwt. of good coke, one large shovelful of lime being added at every second charge; more lime than this is apt to be injurious to the lining of the furnace. Cupolas which melt all day are large, possibly five feet or more in diameter, and require double the charge stated above.

About two years ago some persons went about the country professing to have found out a particularly economical method of charging the cupola; their system was to break each bar of pig-iron into four pieces, build the pieces all round, the

ends close to the lining of the furnace, and fill the space in the centre with coke. Another person recommended a plan exactly the reverse of this; that is, the placing of the iron in the centre, and the coke between the iron and the lining. We may safely affirm that neither of these plans, after being carefully tried, has ever given satisfaction, and this for two reasons:—first, the difficulty of carrying it into execution; and second, after this difficulty had been surmounted the metal was melted too slowly and also too dull. Founders that have any pretensions to turn out good castings would not be troubled to adopt such modes of charging; in fact, it would not pay.

After a careful trial of different methods we believe that the plan of throwing the pig-iron and scrap-iron indiscriminately into the furnace, keeping as near as possible to the centre, and placing the coke well to the outside, is really the best method of charging a furnace. By this method we have found a cupola melt iron more quickly and in better condition, with a man's charging who had never charged before, after he got a simple lesson, than we have known to be the case when any other system has been pursued.

FANS, OR BLOWERS.

Cupolas having undergone so many changes in their mode of formation, the apparatus for producing the requisite supply of air, or "blast," as it is commonly termed, has had to keep pace with these alterations. We have now fans very much improved from the old plain ones, and blowers and blowing engines. Schiele's fan is generally regarded as the most improved now in use; it was introduced in 1868. Root's and Baker's blowers followed, each being supposed by different parties to be the best. Blowing engines are more in use in America, our transatlantic cousins believing that they

ends close to the lining of the furnace, and fill the space in suit their anthracite coal best, and such is the case.

Spretson gives a most elaborate and clear account, in his *Casting and Founding*, of all the fans, blowers, and blowing engines in use for cupolas. This description is well worthy the moulder's attention. The writer seems to infer, (p. 138) that when a cupola is not provided with a fan to produce the proper amount of air, the following is the result: "As the melting proceeds, the tuyeres become foul through the accumulation of slag and cinders in the interior, to such an extent that the melting ceases, and the iron is rapidly decarbonized, loses its fluidity, and is rapidly chilled, so that the castings are bad from being run short, too hard, or unworkable with the tools which follow, and producing much waste." Now to us this seems strange language, we mean the latter part. The tuyeres may and do at times get foul, as Spretson says, and the melting may almost cease in consequence, but what has that to do with casting a mould short? No moulder would begin to pour metal into his mould without fully believing that he had the requisite quantity of iron in his ladle. Castings are not run directly from the cupola, as Spretson seems to imply. Again, the metal does not lose its fluidity, and no change takes place in its character, even if the cupola has been charged with No. 1 pig-iron. No. 1 iron will certainly run from it. The cupola has become "scaffolded," and it would not pay to keep men waiting on their iron; and as the melting tends to get worse, that is, slower, the sooner the cupola is drawn the better, as we have said before. On page 140 of Spretson's work he says:—"Seeing that the highest pressure required is from twenty to twenty-four ounces per square inch, it is impolitic to employ a fan whose duty (highest) is sixteen ounces; not that pressure is a *sine quâ non* for smelting in the cupola, but that in order to introduce the necessary amount of oxygen per lb. of fuel the

internal resistance reach such a point as to cause a corresponding increase in the density of the air." Few cupolas can claim to have a pressure of blast up to twenty ounces. No doubt an extra large one would require this, but we know of no cupola that has it, so that we cannot say what effect a pressure reaching twenty ounces would have. A cupola in Liverpool has two rows of small tuyeres (two inches in diameter) immediately above four large ones of six inches diameter, and we understand that good results are obtained from this plan.

The blast coming from the fans or blowers should run below the stove floor, as this tends to dry the air on its way to the furnace; and the fans should occupy a dry place, damp air being well known to be adverse to the melting of iron. Various plans have been suggested to heat the air for the cupola, and some of them have been tried, but none seem to have produced the results desired. There is no doubt that air heated to a high degree could be supplied for the cupola, but the cost of the requisite heating apparatus would be such that no foundry-master would adopt it. As the air should enter the furnace dry, so should the coke be dry, and as free as possible from sulphur. For this purpose a shed ought to be provided for the coke, it being obvious that coke saturated with water cannot be expected to give forth the heat requisite to melt iron as soon as dry coke.

Before passing from the subject of cupolas, we may, in conclusion, say, that as there are so many different shapes of cupolas, and such varied kinds of apparatus to produce the blast, it is difficult for any one to lay down a hard-and-fast rule and say, this is the thing. The foundry-master, however, should carefully consider and search for the kind of cupola that will best suit his special requirements, seeing that upon a quick melting and an economical furnace depends in a great measure the success of the foundry.

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GATHERING METAL FOR LARGE CASTINGS.

EVILS IN HAVING TOO MANY LADLES.

A casting twenty tons in weight, no matter for what purpose, requires twenty-three tons to be melted, and this quantity two moderate-sized cupolas should be able to produce in good condition for casting in two-and-a-half hours, with three ladles, say two that will carry ten tons each, and one that will carry three tons.

To this mode of gathering metal, however, some objections may be raised, and there are difficulties to be contended with. First, it is argued, and with some reason, that the metal is not properly mixed when in three ladles; in fact, some engineers specify that their castings shall not be cast in this way, the metal must be altogether; and for special castings we believe that such a plan should be adopted. The next trouble that besets the moulder is that sometimes the first filled ladle soon begins to shew symtoms of becoming dull, or sluggish, before the other two are ready; recourse must then be had to the plan of putting extra covering upon it; this is usually done with saw-dust, smithy ashes, or dry blacking, and covering the whole with thin sheet-iron plates. We have seen this a very serious trouble, but happily it seldom occurs; the best—and we might say the only—way to avoid such an evil is to be sure that the coating of loam in the ladle is perfectly dry, and the ladle itself made hot. In order to do this a large fire is usually made in the ladle three hours before the metal is tapped into it from the furnace; the embers or red ashes of the fire float upon the top of the metal, and this of itself, under ordinary circumstances, ought to be a sufficient protection to the metal for a considerable time in any large ladle.

Supposing the three ladles to be now filled and brought

into position for casting, the rubbish and fire are raked off each as quickly as possible ; if one ladle gets cleaned before the other two it must wait until they are done, and it may soon give signs of getting dull. The three being at last ready, the casting or pouring begins. One ladle is rather high, another is as much too low ; one ladle is too easy to turn, and inclines to fall over to the extent of five or six inches, thereby causing a great flow of metal, and possibly overflowing the gutter or head in a great wave of metal, carrying dirt and sand into the flow-gates, and thence into the casting ; another ladle may absolutely refuse to turn after it has become half-empty, until more force is applied to it ; the metal falling from the ladle that is too high has disturbed the sand, causing a commotion by throwing showers of sparks and metal all round, so that the men at that particular ladle are on the point of running from it, and sometimes are actually compelled to do so ; add to this the calls of the men at one ladle to the men at their crane to hoist ; the other crane-men mistake it as being addressed to them, and they hoist when they are not wanted to do so ; eventually, however, though amidst no small uproar, the mould is filled. The result is a very imperfect casting, and if it must be clean it has a poor chance of passing. This occurrence does not happen often, but it does sometimes take place in casting with three ladles, if all things are not carefully looked after. But twenty-three tons of iron can easily be cast from three ladles when the work is properly managed. First, it is essential that the cupolas should be capable of producing the metal in good condition ; second, that the ladles are in good working order and hot ; third, that the metal is well covered from the air ; fourth, that the mould is quite ready ; fifth, that each ladle is properly manned ; sixth and last, that no one directs except the foreman. If these conditions are attended to there need be no fear of the casting.

METAL GATHERED IN ONE LADLE.

When the metal required reaches the weight of thirty tons or upwards, it is usual to provide a special ladle or reservoir for the purpose; this is done by two different methods. First, a ladle may be made of cast-iron plates, provision being made in the shape of flanges for bolting the plates together octagon shape; a bottom plate one-and-a-half inches thick is bolted to the eight side-plates, and the ladle is then ready to be built up inside with bricks and loam to the thickness of at least six inches, a hole for tapping being provided in one of the plates of a proper size to let the metal out when wanted. This ladle may, and is intended to, be lifted about wherever it may suit the mould best. A large trough is now made close up to the tapping-hole of the ladle, about eight feet in length, and three feet deep by four feet broad; this trough to have a gradual fall of four or five inches from the tapping-hole of the ladle, and the lower end being fitted with a loam-plate having a hole eight inches by six. On the face of this last plate is carefully fitted a shutter-plate, covered with loam and dried, it being necessary that no metal should be able to find its way past the shutter during the time the trough is being filled from the ladle. This trough is often made with sand, but we think a loam-trough is best. A bottom-plate, two side-plates, and an end-piece for the shutter are easily made, and the expense of laying a single brick all over them is very little. This may be kept, or, if preferred, it can easily be taken to pieces until it is again wanted. The tapping-hole of the ladle, five inches by four, is carefully rammed hard with sand and blacking in nearly equal parts, a plate covering the hole, with a bar running across. The blacking makes the sand free and open, so that no time may be lost when the ladle is ready for tapping. On the removal of the bar and plate, the sand is found to leave the hole

freely. The ladle and receiver (or trough) must be set sufficiently high above the head of the mould to drain off all the metal that may be in them. Two cupolas supply the metal; a ladle, of capacity to carry three or four tons, being filled from each cupola alternately, soon brings up the required amount. As much fire ought to be in the standing or large ladle as will allow of twelve inches of red cinders to float on the top of the metal; and the ladle itself should be covered over with sheet-iron plates, leaving a space at which the three-ton ladle can be emptied. The trough is covered with sheet-iron plates and sand, in order to keep the heat off the workman, who takes his position by the shutter or sluice. All being ready, the ladle is tapped, and the metal runs wildly into the trough, sending up a cloud of dust, blacking, and sand. The man at the shutter must stand firm, keeping his eye on the metal as it surges and heaves higher and higher until it is within an inch-and-a-half from the top of the shutter, which he lifts, and the metal quickly finds its way into the head. He must note how the mould is taking the metal, that all the gates are supplied, and that he is not overflowing the head. In this way not a word need be heard from any one, and the casting is accomplished, as it ought to be, clean, and without noise.

A large ladle may be built wholly of bricks and loam in a nine-inch wall, swept up with a board like an ordinary loam-mould, strengthening-plates an inch thick being laid on the building at every two courses of bricks, which plates should be seven or eight inches broad. After the ladle is dried and put in position, it requires to be rammed firm with twelve inches of sand round the outside, plates being cast for the purpose of holding the sand and resisting the ramming.

This ladle can, however, be made without ramming, when proper provision is made for the purpose. This is done by making the building-rings an inch-and-a-half thick instead

of an inch only, allowing three inches of loam on the edge of the rings inside, and casting-prods (flat) or dabbers on the outside edge. The dabbers should be strong, say three inches broad, one inch thick, and not more than nine inches long. The plate (or ring) should be cast broad enough to allow the prods to come outside of the brick-work, and the rings to bear upon the dabbers of each other; the last one on the top must have six snugs, to enable the whole to be bolted firmly down to the bottom plate upon which the ladle is built. The object in having three inches of clearance on the edge of the rings is to keep the latter from expanding, so as to prevent breaking, owing to the great heat of the metal. This plan makes a strong ladle, and is, in our opinion, better than that of ramming the outside with sand. These two kinds of ladles are in use where there is no air furnace.

AIR-FURNACE.

The best mode of gathering metal for large castings is that of collecting it in the air-furnace. This might be more appropriately termed a gathering furnace, as it is only used for storing large quantities of molten metal; it is, however, generally called an air-furnace, seeing that it provides its own air through having a long chimney. The form of the air-furnace is as nearly as possible that of an ordinary forge furnace. It is usually built to contain sixty tons of melted metal, but when only thirty tons are required, the bottom is raised with rammed sand to suit. The mode of working this furnace is quite different from that of the cupola. The fuel is coal, the most suitable kind being that which produces the greatest flame.

The air-furnace is usually charged with six tons of pig-iron on the bank, so placed that the flame has free course between the pig bars. Heavy lumps of iron, of three or four tons

each, or even more, may be placed on the bank instead of pig; in this way lumps which are too large and heavy for the cupola may be disposed of. The furnace is always charged before being lighted. When all the metal on the bank is melted, a circumstance which is noted through a sight-hole on the side, the furnace is ready to receive the metal from the cupola. This is done by having an inlet or oblong hole in the lower end of the furnace near the top, the hole being about six inches by four. A shoot or runner made of sheet-iron plate, lined with dry loam, is made sufficiently long to suit the sweep of the crane which is to hoist the metal from the cupola. This shoot has a basin at the end opposite to the air-furnace, so that the metal may be freely and quickly emptied into it. It is supported on a raised scaffold, upon which the men stand.

A three or four-ton ladle is generally used for the purpose of conveying metal from the cupola to the air-furnace. Immediately the ladle is emptied a stopper is put before the inlet to prevent cold air passing into the furnace. Whatever length of time the cupola may take to produce the quantity of metal requisite for the casting, no relaxation must take place in keeping the air-furnace well supplied with fuel, so that a strong flame may be kept continually passing over the top of the melted iron until the requisite quantity is gathered.

The air-furnace has its advantages as well as its drawbacks. The advantages are as follow :—The moulder can rest in assurance of having his iron in first-rate condition ; he need not be afraid of his casting being cold-shot in any part as far as good iron is concerned. The circumstances of the metal being first melted in the cupola, and then run into the furnace, are about tantamount to having it recast, as the different brands of pig and scrap-iron become thoroughly blended. Again, the playing of the flame over the surface of the iron is calculated to extract a great proportion of the

sulphur which permeates all kinds of metal more or less. Last of all, the cast is virtually under the control of one man during the process of filling the mould, the receiver or trough being provided at the front of the furnace in a manner similar to that at the front of the built ladle. On the other hand, the disadvantages of the air-furnace are its first cost, the extra space required for it to be built on, and the extra expense which is incurred in fuel when it is in use. Those are the three primary objections. But in our opinion they are not to be compared with the utility and advantages that an air-furnace possesses in storing a large quantity of metal fit to produce a good, strong, clean, and sound casting. When the weight of any casting, especially cylinders, is upwards of twenty tons, the metal ought certainly to be run from an air-furnace.

CHILLED CASTINGS.

As hot wrought-iron or steel becomes hard when immersed suddenly in cold water, so does cast-iron become hard when, being in a liquid state, it is allowed to come into contact with cold iron. When a certain portion of a casting is required to be made hard, the corresponding part of the mould must be always of cold cast-iron, and well coated with black-lead.

A mould may consist partly of loam or sand and partly of metal. In some foundries moulds of this description are in frequent use.

Wheels for mining districts receive their bores by having a cast-iron and sometimes a steel core, which is slightly tapered to admit of its being freed from the casting by a stroke of a hammer. The casting is never left to cool entirely before the core is removed.

Chilled railroad car wheels represent another article in which iron is employed as a part of the mould, being greatly in use for that purpose in the United States of America.

The outside of the mould, which forms the rim of the casting, is merely a heavy piece of cast-iron, turned or rather bored out in the lathe; but as such castings are specialities, little need be said about them, as the principle of moulding them is just the same as if there were no chill at all.

It may suit our purpose better to consider the effect which the chill has upon the casting, and the effect which the metal has upon the chill, if any. When the casting is thick at a part that has to be chilled, the chill-plate has to be proportionately thick, in order to resist the great heat imparted from the metal, else no chilling would take place. As well might the smith try to temper his steel in warm water as the moulder try to chill his casting on a thin chill-plate. Suppose we take a forge-anvil, say a cubic foot in size, and use a chill-plate an inch thick, very little chilling on the face of this block would result; but suppose the chill-plate to be five inches thick, the casting will then be as hard as steel on the face, the hardness penetrating into the casting three-quarters-of-an-inch. Such is the effect of a heavy chill on heavy metal, decarbonising the metal that lies on the plate to a certain depth, and causing it to become No. 8, or white iron.

Has the circumstance of heavy metal having been often used any effect upon the chill? Our experience teaches that it has an effect, and that not for the better. When a chill-plate has been used several times with heavy metal, the surface of it becomes as it were dead, and begins to produce a rough and ugly face on the casting, the metal actually refusing to lie quietly upon it, owing to the surface of the chill-plate having become non-porous, giving the face of the casting an appearance as if it had been cast in very wet sand. Thus the chill-plate imparts virtue at first to the casting, at the expense of its own. To many readers this assertion may appear strange; but we must bear in mind that it is extra

heavy metal here spoken of, which we know is decidedly different from ordinary chilled castings. Those chills may and do last a conslderable time before they are considered useless.

When a chill-plate four inches thick is broken up, having been in use for some time with heavy metal, it will be seen to be what the moulders understand as "burnt," the face of the chill being burnt in an inch deep, like the top of an old fire-bar that has been long in use, which clearly shews that the chill-plate suffers.

Tools for planing castings can be cast and chilled at the point to a degree harder than common steel; but they will not stand to be tempered in cold water like steel, for when tried in this way they immediately fly into many pieces.

A chill to be used for any purpose may crack on its first use and become useless; in order to avoid this as far as possible it should be cast of the best hematite iron. In the case of roller chills, they are, as a further preventive, bound with wrought-iron rings.

When a chill-plate forms the bottom of any mould the metal can be admitted on the face of the chill with perfect safety, as it soon becomes covered by the metal before the slightest impression is made upon the chill. The chill ought to be perfectly clean and free from rust, as where there is oxide molten metal refuses to lie at peace. It is also advisable to make the chill slightly warm previous to casting.

MALLEABLE CAST-IRON.

In producing malleable cast-iron castings the principles followed in moulding them are much the same as in ordinary castings. All that tends to make malleable cast-iron is in the quality of the iron which fills the mould, and in the annealing process, the latter part being the most important, and which is patented.

The manufacture of so-called malleable-iron castings requires No. 5 brand (hematite) as metal in which there is little carbon, and that little in a combined state. It is a white metal, parting easily and equally with its carbon in the annealing operation. It may be melted in the cupola in the same manner as ordinary iron; but in the case of the best class of malleable cast-iron, it is melted in crucibles, or in a small furnace for the purpose. The shrinkage of this hard iron is greater than in grey iron, being as nearly as possible a quarter-of-an-inch to the foot. Fred. Overman says that the manufacture of malleable iron castings is older than is generally supposed. Although the knowledge of the true principles on which it is based dates from the more recent period of the establishment of chemical science, and though in 1722 a Frenchman, whose name was Raumur, experimented with cast-iron to produce malleable iron, and succeeded, yet the process had been effected twenty years before that time, but in a secret manner. Raumur found, in his experiments, that oxides of iron and cast-iron, heated together in closed vessels, produced malleable iron.

Malleable castings are now extensively in use, even up to the weight of three and four tons, such as water-press cylinders for callender works, which are subjected to a great pressure, up to seven thousand lbs. on the square inch. They used to be cast with ordinary iron, seven inches thick round the barrel; but they are now made from malleable cast-iron, only three inches thick, and they resist successfully the enormous pressure put upon them, which in many instances the seven-inch ones could not stand, they often being rent from top to bottom. Again, the same kind of castings are now frequently used for heavy and important parts connected with large marine engines; and for tools of all descriptions malleable cast-iron is now extensively used. The art is to cause this chemical change to take place in the metal after the

castings are made and relieved from the moulding-sand. They are then arranged in boxes of iron made for the purpose, every casting having to be carefully covered up, and resting upon scales of iron from rolling-mills and ground red hematite ore, and then run into a furnace prepared for the purpose.

This furnace is raised and kept to an exceedingly high temperature, and according to the thickness of the casting so the time the castings are kept in the furnace. We understand four or five days and nights are required to anneal some heavy castings. With ordinary castings two days and nights are considered sufficient; but the length of time required to anneal castings wholly depends upon the article to be annealed.

Small iron castings are freed from the moulding-sand by being put into a close revolving cylinder, and then packed in boxes with the material already mentioned.

So thoroughly has malleable cast-iron superseded the real malleable iron, and to such innumerable purposes is it devoted, that it is very difficult to actually determine, in many instances, what is the real malleable iron and what is malleable cast-iron.

CHAPLETS, AND THEIR USE.

Chaplets are intended to carry up cores to whatever thickness the metal is intended to be, which is usually from half-an-inch up to three or four inches; not only are they intended to carry up the cores, but they are also used for keeping the cores down in their proper places. They are most used in marine-engine castings, either in dry-sand or loam moulds; and also for such castings as cylinders, condensers, sole-plates, pistons, covers, &c.

We cannot state here when and where and of what strength chaplets should be put in a mould, because moulds

are so varied in form, and so much depends upon circumstances. Thus, a weak core-iron requires extra support here, or a weak part of the mould needs to be helped with a chaplet there; in fact, so many exigencies occur which require, in the moulder's judgment, the use of a chaplet, that no rule can be properly laid down for the use of them. This, however, we may safely say, that the fewer chaplets there are in a mould the better the casting, its safety being also considered.

The evils that are attendant on chaplets are twofold. In some cases they are very apt to encourage a casting to crack, especially when there are many of them spread over the top of a core, say on a large condenser an inch-and-a-quarter thick, or on a flat plain surface in any casting. The chaplet tends to weaken the plate, as the malleable iron is quite foreign to the cast iron. In the second place, should the chaplet have the least impurity on it, such as oxide or rust, this is apt to produce holes in the metal, or a porousness all round the region of the chaplet. The oxygen from the impure chaplet combines with the carbon of the cast-iron and forms carbonic oxide gas, which is prevented from escaping by the pressure of the liquid iron; it therefore holds its place, and makes clear holes—large and small—all round the chaplet. These holes or porousness may not be seen on the face of the casting, either inside or out; still in many cases they exist, as can plainly be seen when old castings, and sometimes new ones, that have had chaplets in them are broken up. It will be noticed, then, how apt steam—especially high-pressure steam—is to cause mischief, when it happens to come in contact with a part where a chaplet is bedded in porous cast-iron. To obviate or reduce this carbonic oxide the moulder has tried many things with his chaplets, such as rubbing them slightly with oil, red lead and turpentine, or coal-tar, dipping them in a mixture of lead and tin, making them red in a fire, and so on. The mixture of

tin and lead is very good, but the plan of making chaplets clean with fire is better. Tinned chaplets are greatly used, as they do not rust easily, and time and trouble are saved by using them. This latter is the sole reason why tinned chaplets are sought after.

Chaplets are a source of weakness to any casting, especially when there are many, and they happen on the part of a casting which is cast up, *i. e.*, the moulder's top. When they are placed in the bottom of the mould, or even when used for the purpose of staying, sometimes called "jamming," the cores between themselves, or between the outside of the mould and the core adjoining the outside, they are much less injurious. The pressure of the metal in this instance is greater and the metal cleaner, which circumstances go far to counteract the ordinarily evil influence of chaplets. No moulder in loam or dry-sand, and in many instances in green sand, can dispense with them; but they are often put to an indiscriminate and needless use by even good moulders, thus causing not only harm to the castings, but unnecessary expense to the master. Nothing pains a proper moulder's eye so much as when he looks into a mould that is being closed or put together and sees chaplets here and there where there is no use for them, looking as if they had been shaken out of a riddle. Some moulders can hide double the quantity that others do in making a casting from the same pattern. Why is this? Simply because a first-class moulder thoroughly understands what part of his mould really requires chaplets.

The common chaplet for loam and dry-sand is merely a piece of stout hoop-iron nine inches long, with three flat-headed nails rivetted into it, the nail-stalk having a good shoulder for the hoop-iron to rest upon. The green-sand chaplet is simply a piece of rod-iron, from $\frac{3}{16}$ths of an inch diameter or square up to three-quarters-of-an-inch, which is termed the stalk, and made to suit the job, a piece of hoop-

iron or stout plate (as the case may be) being rivetted at the end of the stalk of from an inch-and-a-half up to four or five inches in length, according to circumstances.

Some castings are bad, and some faulty, owing to the core or cores rising from their proper places when the pressure of metal comes upon them. This may not be from the want of chaplets, but because the chaplet has sunk into the core, or the nails have been pressed into the top part. The metal in either case will be thin above the core.

The foregoing description of chaplets may serve for a mould in which there is no great lift upon the cores; when, however, the pressure is very great, they are wholly inadequate, and something else must then be done. When the moulder considers that the ordinary or common chaplet will not hold down his core, unless indeed he uses a great many of them, which, as we have already shewn, is distinctly bad, he should, in making his core, raise up iron props at proper intervals from the main core-iron to within an inch from being flush with the core. Holes must be made in the top part to admit a piece of round or square iron of a proper strength, say from half-an-inch up to one inch, to rest upon the iron props in the core. These irons, or chaplets, as they are sometimes called, are then bound fast to the top part, or the bar running over the top part, which prevents the core from moving. The core of a large condenser, or other heavy casting, may be held in its place with six of these chaplets, making little or no mark in the casting, whereas it would take thirty-six ordinary tinned chaplets to do the same work, indeed we question if it could be done with even that number.

Large columns, cast horizontally in sand, should never be cast without chaplets of this kind, as the core is bound to be in the centre of the casting. The pieces of iron leading to the iron props from the core-bar, or core iron, can be covered with a coating of loam and blackened; they can then be

taken out of the casting, leaving a clean hole like a core-hole, which can be easily tapped up, when the thickness of the metal can at once be noted. Where numbers of columns are made and contracted for this is what should be done. The inspector of the casting would then have no trouble in knowing at once the thickness of the column. The hole would only be an inch-and-a-quarter at the most, not in the slightest degree weakening the casting. The metal runs kindly and smoothly round this loamed chaplet, no honey-combing can take place here, and in our opinion it is the very best of chaplets.

The reason for keeping the iron props an inch or so from the surface of a large core is to allow the casting to contract. The props on a large pipe or column core-bar or spindle may be kept flush with the core, as the casting has ample liberty to contract from the space in the under-side of the core-bar or spindle. To do this requires extra time and labour on the moulder's part ; and we apprehend that where there is keen competition among moulders for work in which it should be done, and piece-work prevails, this requirement of extra labour is the main reason why it is not always done, the common stalk chaplet being resorted to in the sand column, and a greater number of three-studded chaplets in the dry-sand and loam castings.

Cast-iron chaplets can be used to great advantage in staying or jamming cores, care being taken that they are not in the way of any running gates, as in that case they would quickly melt ; neither should wrought-iron ones be in the way of gates, as they also would quickly disappear.

A three or four-inch round core the exact thickness of the metal, made strong with iron, and resting upon a strong part of a main core, makes a capital chaplet, when it is placed upon a part of the casting to which access can be had to tap them up. Engineers prefer to tap these holes rather than

see a host of chaplet nail-heads shining through the skin of the casting.

Twenty years since chaplets were commonly made with double-plated instead of flat-headed nails, that is, with three studs rivetted between two stout hoop-iron plates, for the sole purpose of being more able to resist the pressure of the metal, by affording a larger surface to prevent them from sinking into either the mould or the core. Nothing could be seen more ugly at that time on a casting than these hoop-iron plates shining and sticking in numerous instances all over it; but, like the progress of other things, chaplet-making and the proper use of chaplets have wonderfully improved.

SHOP MANAGEMENT.

The person who has control over a casting shop ought to possess two qualifications; first, he should be able to manage or control himself; second, he ought to be thoroughly conversant with the work, in all its branches, that has to be carried on under his direction. A man who is continually losing control over his temper soon ceases to be respected by his subordinates, and in proportion as he does this he loses control over them. A man will at times lose his temper, but it ought to be as seldom as possible, and then only when he has a just reason. He should be a competent workman in every detail—able to know when a man is working to some intent, or frittering away his time—able to discern what a man really can do, and place him at the kind of work that he is suited for—able to discern the character of a man, and to know when he is working cheerfully or the reverse—able to read his men and shop like a book, from the youngest apprentice to the oldest journeyman, and to tolerate no shouting or undue noise. Familiarity breeds contempt; the foreman's distance from the men ought to be such as to promote respect,

and yet not so much as to preclude them from speaking to him. He ought always to be ready to assist and encourage anyone who has got into difficulties with his work, provided that such difficulties have arisen from errors of judgment. He should evince no partiality, and shew no favour, treating every workman alike. He ought to have a mind of his own on the work, and yet not be above taking a hint from a labourer. In this respect he should fear neither master nor men, as they are both quick at detecting anything of that kind, and neither party is slow to take advantage of it.

A foundry when busy seems to the visitor a place of confusion, and the thought strikes him—Could it not be kept in better order than this ? More especially is this apt to be the case on the morning after a cast. In the sand department heaps of dried sand, boxes empty and half-empty, scraps, gates, runners, and castings may all be lying in juxtaposition to each other. In the loam department are to be seen great holes in the floor, rough-looking buildings of bricks in these holes or pits, a lot of bricks on the floor, boxes of dirty-looking loam, bruised buckets containing dirty water, blacking, and clay-water, ashes, bricks, core-irons, straw ropes and loose straw, sawdust, chains, beams, ropes, and many other things, all of which give the foundry an air of confusion. On this account the visitor should come in the middle of the day, when all things have got put into order. All the things, however, that we have mentioned are of use to the moulder, who is continually using them. Some foundries are much worse than others in this respect. The construction of the foundry has a deal to do with it, in not allowing easy and free access to a yard; bad management has also something to do with it, the foreman, for the sake of economy, doing with less labourers than he ought to have for the work in hand; but this is not really economy; the foreman may be employing fewer labourers, but on this account

he is not getting sufficient work from the moulders, so that where he saves on the one hand he loses on the other. After all that has been said, however, it is the duty of a moulder to discern when a foundry is kept in proper order.

THE FORMATION OF A FOUNDRY.

No one can properly say much on this subject unless he first knows what class of work it is proposed to carry on. Foundries where only one class of work is engaged in require to be very different in design from those of a totally different class. A foundry where nothing but grate-metal and hollow work is carried on will be very different from another in which only railway chairs are cast, and that again different from one which produces nothing but pipes made by machinery. Their requirements are so varied, and the necessities of each so peculiar to itself, that, as we have already observed, no one can properly lay down a hard-and-fast line as to what is the best form of a building for a foundry without first knowing to what purpose it is to be devoted. But suppose we take a general foundry, otherwise called a jobbing foundry, where all three branches are to be carried on, from the lightest to the heaviest of castings.

The best plan for such a shop is of an L shape, one part being devoted to green and dry-sand, the other to loam. The foundry-building in this case embraces the yard. The roof should be high, capable of giving plenty of light, and well qualified to keep out wet. The smoke that arises from the pits requires that the roof should be extra high. The cupolas and air-furnace (and no foundry where heavy work is done should be without the latter), as well as the pits and stoves, can be well placed in a foundry of this shape. It is, as it were, two shops having easy access to the same yard; and yard-room, with easy facilities for going to and from them,

is a most important consideration to the moulder.

Steam travelling-cranes are better than jibs, provided that light jib-cranes are distributed at proper intervals throughout the shop, as a twenty or thirty-ton over-head steam-crane cannot work the light parts of a mould in closing or parting with the requisite steadiness.

Sometimes the position of the site chosen, or other circumstances over which there is no control, may influence the plan of a foundry; but of whatever plan it may be, a wide and ready outlet to a space of ground for boxes and plates is most essential; the foundry should be used only for moulding.

Many foundries clean their large castings in the yard without any covering, but this is not good either for the men or the castings; men cannot work so well when uncomfortable with wet, and the castings are not so quickly or so well cleaned when they get wet; provision should therefore always be made at the extreme end of the foundry for cleaning both heavy and light castings.

WEIGHTS OF CASTINGS.

It is very important that a moulder should know what quantity of metal is requisite to fill his mould. We cannot think of a more galling and annoying matter than to have a well-made mould cast short of metal, and more especially is this felt when probably two weeks have been spent in making it ready for casting.

When we consider the loss to the employer in waste of material, wages, wear and tear of plant, and sometimes the casting is wanted urgently, it becomes a serious matter when too little metal has been provided, not only with a large mould, but equally so with ordinary or small castings.

Twenty years ago, when a twenty or thirty-ton casting was made, it was usual to have about ten tons more of metal than

was required, and yet it was not uncommon for the casting to be short. But in these days of keen competition, when economy is the watchword, the moulder can neither have the one nor the other; the expense in melting more metal than is absolutely required for the mould and heads, and the breaking up of that metal, will not now be tolerated, much less will they be allowed to be cast short. It therefore requires the moulder to measure his pattern carefully, and also the mould, totalling the whole up in feet or inches. We will now give a few easy rules, which we are sure every moulder will be able to understand, and to put in practice :—

Flat Iron.

The weight of a superficial foot of cast iron an inch thick is 37·84 lbs., but there is no real necessity for a moulder using the above. The weight of a malleable iron plate the same size is 40 lbs. These latter figures will suit the moulder better, as the $2\frac{3}{4}$ lbs. extra make up for any irregularity that occurs in moulds; and it is an easy sum to multiply any number of feet by; for every eighth part more add 5, and for every eighth less than an inch deduct 5.

For example, a plate 6 feet square and 1 inch thick :—

$$6 \times 6 = 36$$
$$40$$
$$1440 \text{ lbs.}$$

The actual weight in cast iron is 1363·392

77 lbs. 6 oz. difference.

Rule 2.

Multiply breadth by thickness in inches, and by 10 as a constant, divide by 3 as a constant, and by the length in feet.

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Example :—Breadth=72 inches

10

3)720

240

6 Length in feet

1440 lbs.

Wrought-iron rule, and may be used for cast iron.

Rule 3.

It is easily remembered, and quite as much to the moulder's purpose, to consider every 3 square feet 1 inch thick=1 cwt.

Round Plates.

To find the number of feet contained in a round plate of any given size :—

Square the diameter, and multiply the product by ·7854.

Example.

A plate 3 feet diameter

·7854
= 9
7·0686

Very little more than 7 feet is in this plate.

Cylindrical Bodies.

When the mould is of a cylindrical form, multiply the diameter by 3·1416 and by its length; the number of feet will then be had, cutting off the four right hand decimal figures, or, to be quicker and quite near enough, multiply the diameter by 3, adding a foot to every 22.

Example. Diameter 11 feet.

3

Add { 33
1½

Answer 34½ feet

Diameter 11 feet

3·1416
11
34·5576

Answer 34 feet 6¾ inches.

Spherical or Round Balls.

Cube the half of any given diameter in inches and divide by 10 as a Constant.

Example. Diameter 8 inches, the half 4, cubed 64.

Divide by a constant number 10)64 } Add
6·4 }

Answer, exact weight in lbs. 70·4 cast iron.

Round Bars, in Cast Iron.

Multiply the square of the diameter in inches by the length in feet, and by 2·5 :—the product will be the approximate weight in lbs.

Example. A round bar of iron diameter 3 inches, length 2 feet.

$3 \times 3 = 9 \times 2 = 18 \times 2{\cdot}5 = 45{\cdot}0$ lbs.

Pipes, One Lineal Foot.

Subtract the square of the inside diameter from the square of the outside diameter, then multiply the difference by 2·45, the answer will be in lbs.

Example. A pipe 5 inches outside, and 4 inches inside, 1 foot in length.

Outside	$5 \times 5 = 25$	2·45
Inside	$4 \times 4 = 16$	9
	9	22·05 lbs.

The specific weight of cast iron is 16 times heavier than common soft wood.

The foregoing simple rules all moulders may easily remember; they have only to be careful to find the number of feet in the mould, and the rest is easy.

He must consider how much metal should be provided so as to fill the head or gutter, so that the casting may have pressure; then, of course he must know what the ladle or ladles will carry when they are clean. When the ladle is not

quite clean, or the metal seems to be dull, an extra quantity should be provided, as a portion of the metal clings to the ladle in either case. In all very large and important castings it is better to have two tons more than may be actually required for the mould and heads. Provision can be made to use the surplus either for an open sand plate on the bed or a small mould provided for the purpose.

Moulders are accustomed to the use of ropes and chains, and we have thought fit to give the following simple rules, so that they may have some idea of their relative strengths, when the chain or ropes are known, or supposed to be, in good condition :—

Ropes.

Mr. Hogg says, to ascertain the strength of hempen ropes, square the circumference of the rope in inches, divide by 5, and the answer is in tons or parts.

Example. Circumference $3 \times 3 = 9 \div 5 = 1{\cdot}8$ or 1 ton 16 cwt.

Breaking strain, 2 tons 5 cwt. Admiralty test.

Common Rope.

Mr. Molesworth says, square the circumference in inches and multiply by ·2. Answer is breaking strain.

Example. Circumference $3 \times 3 = 9 \times {\cdot}2 = 1{\cdot}8$ or 1 ton 16 cwt.

Breaking strain rule for hempen ropes :—Multiply the square of the circumference by ·28.

We adopt the following rule of our own for safe working :—

Hempen rope : square the circumference in inches, and multiply by 4 ; the answer is in cwts.

For common rope multiply by 3, and the answer will be in cwts.

Chains, Short Link.

Mr. Hoare says, for chains, safe working, square the diameter in eighths and divide by 8.

Example. $\frac{3}{4} = \frac{9}{8} = 36 \div 8 = 4{\cdot}5$ Answer, 4 tons 10 cwt.

Admiralty proof for this chain, 6 tons, breaking strain, 10 tons 4 cwt. Many parties think 8 too high as a divisor, and adopt 6. We think 8 is safer for sling chains that are in constant use.

NOTE.

To find the breaking strain—Square the link in eighths, and multiply by ·356.

To find the proof strain in tons—Multiply the square of the link in eighths by ·188.

Chains and ropes become defective through constant use; the defects in ropes can be easily seen, but not so in chains. It is well known that a chain may safely carry thirty tons one day, and the day following break with twelve tons, although the former may have been little more than the safe working strain, the reason being, that owing to constant rattling, severe shaking, and violent jerks, the iron in the link has slightly changed its character; from being fibrous it has become short in the grain, and when broken, the fracture presents a cast-iron appearance, and is apt to cause an impression that the iron composing the chain has been made from bad material. This we believe to be in many instances an error, because when the short-grained broken link is taken to the fire, brought to a bright red heat, and allowed to *cool slowly*, the link on being again broken will shew quite a fibrousness in the fracture. This, in our opinion, clearly demonstrates that all sling and crane chains ought to be periodically made to a bright red heat, but unless provision is made for their slow cooling the heating will do no material good.

In the chain that carried the thirty tons weight one of the links may have been on the eve of parting, yet not be perceptible to the eye, and when it had the twelve tons to carry, a slight jerk on going round the barrel of the crane would be sufficient to break it. The strength of a chain, however,

in a great measure depends upon its use and abuse, irrespective of any hard and fast rule that may be laid down.

GENERAL REMARKS.

There is a peculiarity about moulding upon which too much stress cannot be laid, namely, that a piece of work can *only be done once*, and if it is imperfect in any essential particular it is spoiled, and cannot be used for any other purpose, so that it must be broken up for scrap, and the work commenced *de novo*. A commercial man may correct his correspondence—the designer may modify his plans during the progress of construction—the joiner or pattern-maker can replace a spoiled piece of wood—the smith can alter a forging, or use up the iron for another purpose—the boiler-maker can re-caulk the rivets, the landings of his boiler, and so on; but in moulding, the neglect of some trifling thing may damage the whole casting, and it must be condemned. We venture to point out with pardonable pride, considering the slightness of the causes of bad castings, how very few are spoiled.

Engineers do not hold moulders in the highest esteem, but we think the reason must be their want of knowledge of the difficulties of the moulder's art, and the full importance of his work, for it must be borne in mind that by far the greatest weight of the metals used in the construction of machinery is cast-iron. We also take this opportunity of pointing out that incompetent persons, as engineers, are sometimes appointed to examine castings, with occasionally the power of condemning them. A lad beginning his apprenticeship goes to be an engineer; he spends a few months in all the different shops, except (be it noted) the foundry, and finishes off in the drawing office. What pretension such a youth can have to the knowledge to examine castings and converse about various metals and the mixing of them is

not quite apparent; yet positively it is to such persons, in many cases, that the overlooking and inspection of castings is entrusted; and by this means the moulder suffers. It is sometimes laid to the charge of moulders that they hide the faults of castings. Now, although we strongly condemn this practice, under all circumstances, we still admit a slight excuse for the moulder doing so when he knows that they are to be overlooked by an incompetent person, who may make a trouble about a mark on the surface from ignorance of its real nature and cause, but which affects the casting only in appearance.

This treatise has been written for both engineers and moulders, and although to the latter much of it must be quite familiar, still it is to be hoped that in many cases we have succeeded in drawing their attention more forcibly than it would otherwise have been to many important points of the subject.

It is emphatically claimed for the matter of this book, except where quotations from the works mentioned in the preface have been made, that it is in a great measure original, as no book on the subject hitherto published has treated of the actual practice of moulding. It is also a record of the extensive experience of the author, who has been actively engaged in the practice of moulding in England, Scotland, Ireland, the West Indies, and America.

In conclusion, we would address apprentice moulders—by whom we hope this book will be much read—in the following words of advice—"Strive to be master of your trade and to excel in it; wish rather for that than a big pay, as the pay is bound to follow; be always ready to give attention to your foreman's advice, and never think any work beneath you, as in such a trade as moulding something can be learned in work however mean."

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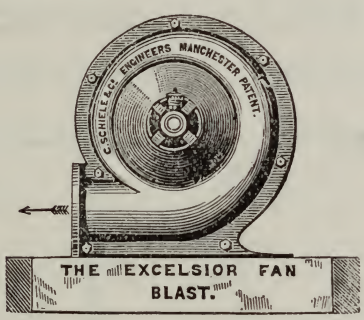

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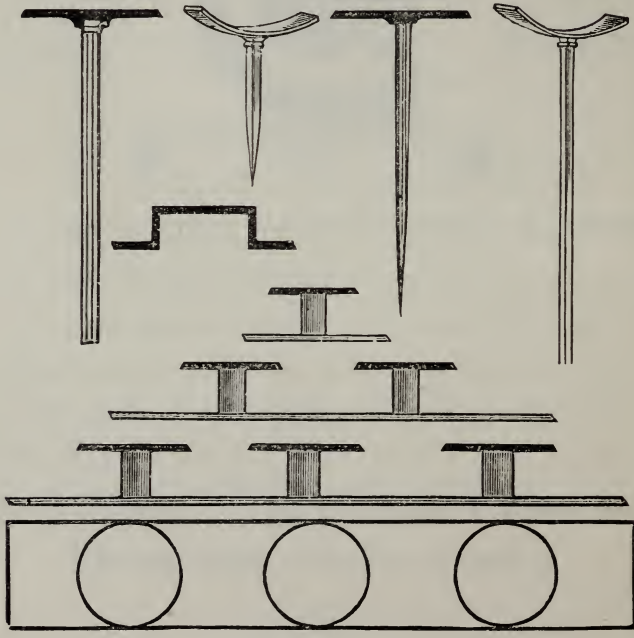

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